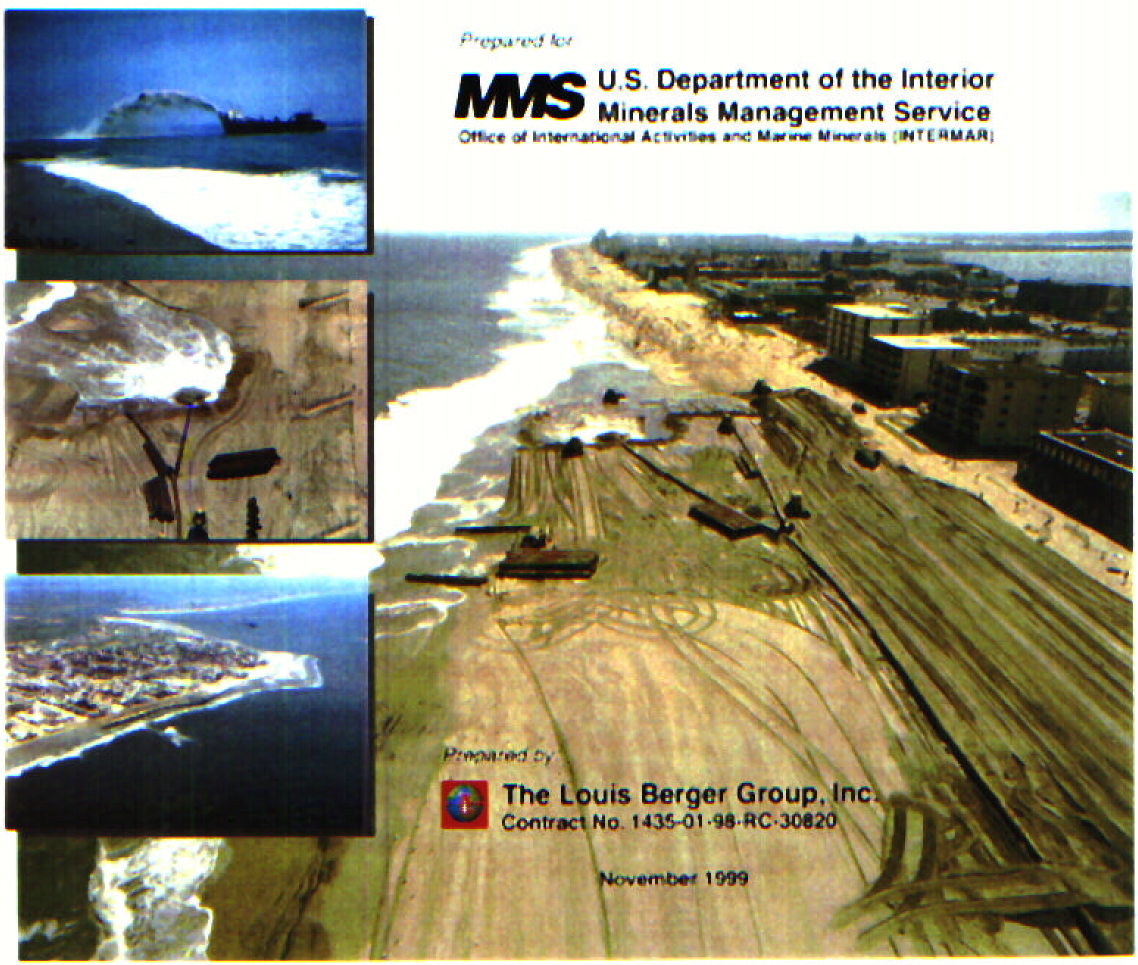
OCS Study
MMS 99-0036

Environmental Report

Use of Federal Offshore Sand Resources for Beach and Coastal Restoration in New Jersey, Maryland, Delaware, and Virginia



Prepared for

MMS U.S. Department of the Interior
Minerals Management Service
Office of International Activities and Marine Minerals (INTERMAR)

Prepared by

The Louis Berger Group, Inc.
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DISCLAIMER

CONVERSION FACTORS

Metric to U.S. Customary

Multiply	by	To Obtain
millimeters (mm)	0.03937	inches (in)
centimeters (cm)	0.3937	inches (in)
meters (m)	3.281	feet (ft)
kilometers (km)	0.6214	miles (mi)
square meters (m^2)	10.76	square feet (ft^2)
square kilometers (km^2)	0.3861	square miles (mi^2)
hectares (ha)	2.471	acres
liters (l)	0.2642	gallons (gal)
cubic meters (m^3)	35.31	cubic feet (ft^3)
cubic meters (m^3)	0.0008110	acre-feet
milligrams (mg)	0.00003527	ounces (oz)
grams (g)	0.03527	ounces (oz)
kilograms (kg)	2.205	pounds (lb)
metric tons (t)	2205.0	pounds (lb)
metric tons (t)	1.102	short tons
Celsius degrees (ºC)	1.8(ºC)+32	Fahrenheit degrees

U.S. Customary to Metric

Multiply	by	To Obtain
inches	25.40	millimeters
inches	2.54	centimeters
feet (ft)	0.3048	meters
fathoms	1.829	meters
miles	1.609	kilometers
nautical miles	1.852	kilometers
square feet	0.0929	square meters
square miles	2.590	square kilometers
acres	0.4047	hectares
gallons	3.875	liters
cubic feet	0.02831	cubic meters
acre-feet	1233.0	cubic meters
ounces (oz)	28.35	grams (g)
pounds (lb)	0.4536	kilograms
short tons (ton)	0.9072	metric tons
Fahrenheit degrees	0.5556(ºF – 32)	Celsius degrees

SEDIMENT GRAIN SIZE CLASSIFICATIONS AND DESCRIPTIONS OF GRAIN SIZE DISTRIBUTION

Summary of the Udden–Wentworth size classification for sediment grains (after Pettijohn *et al.* 1972)(from Leeder, 1982)

	US Standard sieve mesh	*Millimeters*		*Phi (ϕ) units*	*Wentworth size class*
GRAVEL	*Use wire*	4096		–12	
	squares	1024		–10	boulder
		256	256	– 8	
		64	64	– 6	cobble
		16		– 4	pebble
	5	4	4	– 2	
	6	3.36		– 1.75	
	7	2.83		– 1.5	granule
	8	2.38		– 1.25	
	10	2.00	2	– 1.0	
SAND	12	1.68		– 0.75	
	14	1.41		– 0.5	very coarse sand
	16	1.19		– 0.25	
	18	1.00	1	0.0	
	20	0.84		0.25	
	25	0.71		0.5	coarse sand
	30	0.59		0.75	
	35	0.50	1/2	1.0	
	40	0.42		1.25	
	45	0.35		1.5	medium sand
	50	0.30		1.75	
	60	0.25	1/4	2.0	
	70	0.210		2.25	
	80	0.177		2.5	fine sand
	100	0.149		2.75	
	120	0.125	1/8	3.0	
	140	0.105		3.25	
	170	0.088		3.5	very fine sand
	200	0.074		3.75	
	230	0.0625	1/16	4.0	
SILT	270	0.053		4.25	
	325	0.044		4.5	coarse silt
		0.037		4.75	
		0.031	1/32	5.0	
		0.0156	1/64	6.0	medium silt
	Use	0.0078	1/128	7.0	fine silt
	pipette	0.0039	1/256	8.0	very fine silt
CLAY	*or*	0.0020		9.0	
	hydro-	0.00098		10.0	clay
	meter	0.00049		11.0	
		0.00024		12.0	
		0.00012		13.0	
		0.00006		14.0	

Sorting and skewness values for graphically-obtained statistics expressed as verbal descriptive summaries (after Folk 1974) (from Leeder 1982).

Standard deviation (sorting)	*Verbal description*
0–0.35ϕ	very well sorted
0.35–0.50ϕ	well sorted
0.50–0.71ϕ	moderately well sorted
0.71–1.00ϕ	moderately sorted
1.00–2.00ϕ	poorly sorted
2.00–4.00ϕ	very poorly sorted
4.00+ϕ	extremely poorly sorted
Skewness	
+1.00–+0.30	strongly fine-skewed
+0.30–+0.10	fine-skewed
+0.10––0.10	near-symmetrical
–0.10––0.30	coarse-skewed
–0.30––1.00	strongly coarse-skewed

ENVIRONMENTAL REPORT

Use of Federal Offshore Sand Resources for Beach and Coastal Restoration in New Jersey, Maryland, Delaware, and Virginia

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LIST OF ACRONYMS

ACES – Automated Coastal Engineering System
AQCR – Air Quality Control Region
ASMFC – Atlantic States Marine Fisheries Commission
ASTM – American Society of Testing Materials
ATOS – Anti-Turbidity Overflow System
AVHRR – Advanced Very High Resolution Radiometers
BLM – Bureau of Land Management
BMP – Biological Monitoring Program
BOD – Biological Oxygen Demand
BP – Before the Present
CAA – Clean Air Act
CAAA - Clean Air Act Amendments
CeTAP – Cetacean and Turtle Assessment Program
CHL – Coastal and Hydraulics Laboratory
COA – Corresponding Onshore Areas
COLREGS – International Collision Regulations
CRC – Stockton State College Coastal Research Center
DGS – Delaware Geological Survey
DOI – Department of the Interior
EEZ – Exclusive Economic Zone
EFH – Essential Fish Habitat
EPA – U.S. Environmental Protection Agency
ER – Environmental Report
FMP – Fishery Management Plan
FUDS – Formerly Used Defense Site
HAPC – Habitat Areas of Particular Concern
HARS – Historic Area Remediation Site
ICES – International Council on Exploration of the Seas
INTERMAR – International Activities and Marine Minerals
MAFMC – Mid-Atlantic Fishery Management Council
MARPOL – International Marine Pollution Regulations
MGS – Maryland Geological Survey
MLW – Mean Low Water
MMPA – Marine Mammal Protection Act
MMS – Minerals Management Service
MPRSA – Marine Protection, Research, and Sanctuaries Act of 1972
NAAQS – National Ambient Air Quality Standards
NDZ – No Discharge Zone
NEFMC – New England Fishery Management Council
NEFSC – Northeast Fisheries Science Center
NEMO – Network for Engineering Monitoring of the Ocean
NEPA – National Environmental Policy Act
NGVD – National Geodetic Vertical Datum
NHPA – National Historic Preservation Act
NJBPN – New Jersey Beach Profile Network
NJDEP – New Jersey Department of Environmental Protection
NJGS – New Jersey Geological Survey

NMFS – National Marine Fisheries Service
NOAA – National Oceanic and Atmospheric Administration
NPS – National Park Service
OCS – Outer Continental Shelf
OCSLA – Outer Continental Shelf Lands Act
OSP – Optimum Sustainable Population
OTR – Ozone Transport Region
PBR – Potential Biological Removal
PM_{10} – Particulate Matter with Diameter > 10 µm
PM_{25} – Particulate Matter with Diameter > 25 µm
PRA – Primary Remediation Area
PSD – Prevention of Significance Deterioration
SAFMC – South-Atlantic Fishery Management Council
SFA – Sustainable Fisheries Act
SIP – State Implementation Plan
SL – Stock Level
T - S – Temperature-Salinity
TAT – Trans-Atlantic Telecommunications
TIR – Thermal Infrared Radiation
TSH – Trailer Suction Hopper
TSS – Traffic Separation Schemes
USACE – U.S. Army Corps of Engineers
USCG – U.S. Coast Guard
USFWS – U.S. Fish and Wildlife Service
VDEQ – Virginia Department of Environmental Quality
VIMS – Virginia Institute of Marine Science
VOC – Volatile Organic Carbon
WES – Waterways Experiment Station
WIS – Wave Information System
YOY – Young-of-Year

1.0 INTRODUCTION

The Department of the Interior (DOI) has the responsibility for managing the development of the submerged lands of the continental shelf seaward of state territorial waters which lie from the shoreline to 3 nautical miles offshore. This federal jurisdiction was first mandated under the 1953 Outer Continental Shelf (OCS) Lands Act (43 U.S.C. § 1331 et seq.; 43 U.S.C. § 1801 et seq.). Under this Act, the Secretary of the Interior bears direct responsibility for administration of oil, gas, and mineral exploration; for development of the OCS; and for formulation of regulations to meet provisions of the Act. The Bureau of Land Management (BLM) was designated by the Secretary of the Interior to administer leasing of submerged federal lands and the Geological Survey to supervise production. In May 1982, these functions were centralized under the Minerals Management Service (MMS). Within MMS, the Office of International Activities and Marine Minerals (INTERMAR) functions as a liaison for agency involvement in international activities and provides policy direction for management and regulation of marine mineral resource activities on the OCS for minerals other than oil, gas, and sulfur.

Public Law 103-426 (43 U.S.C. 1337(k)(2)), enacted October 31, 1994, gave the MMS the authority to negotiate, on a non-competitive basis, the rights to OCS sand, gravel, or shell resources for shore protection, beach or wetlands restoration projects, or for use in construction projects funded in whole or part by or authorized by the Federal Government. The Shore Protection Provisions of the Water Resource Development Act of 1999 (S. 507 as passed by Congress on August 4, 1999) amended that law by prohibiting charging non-Federal interests a fee for using OCS sand. For all other uses, such as private use for commercial construction material, a competitive bidding process is required under Section 8(k)(1) of the OCS Lands Act which also provides for issuing leases competitively for hard minerals on the OCS.

Beach nourishment projects have historically relied upon sand resources which were available in nearshore or State waters. However, in recent years, supplies of nearshore sand have diminished or been deemed unsuitable due to repeated use and pollution. Continual dredging within the coastal area, within the influence of the nearshore wave base, has also resulted in adverse changes in the local wave climate and physical oceanographic regime. Waves traversing over deep pits and holes created from the continued use of the same nearshore borrow sources dramatically increase in height as they approach the shore and actually accelerate erosion of the adjacent beach. In many cases, sand is still available within State waters. The Federal sand may represent a future source of sand for beach nourishment, as well as sand for emergency purposes should a violent storm event necessitate using Federal sand.

The severe storm damage inflicted upon the east coast of the U.S., along with diminishing supplies and environmentally unsuitable nearshore sand, have increased the demand for resources on the Federal OCS as a source of borrow material for beach nourishment projects. Such sites are needed for both planned projects and for emergency nourishment projects after the passage of severe coastal storms. Studies have indicated that there is a plentiful supply of clean, compatible sand for beach restoration on the OCS and, in most cases, this sand is located in areas well beyond the local wave base and nearshore wave climate regime.

The risk of storm damage to coastal communities will likely be exacerbated in the future due to sea level rise. Global warming is expected to raise sea level and may increase the frequency of storms as well. As global temperatures rise, ocean waters will warm and expand. According to a report prepared by Titus and Narayanan (1995), the odds are 50-50 that greenhouse gases will raise global sea level at least 15 cm by the year 2050 (26 cm in the New York area), 35 cm by 2100 (55 cm in the New York area), and 80 cm by 2200. There is a 1-in-40 chance that changing climate will raise sea level 35 cm by 2050, 80 cm by 2100, and 300 cm by 2200.
Recently, the MMS has provided sand in Federal waters for several projects. Through a negotiated agreement with the U.S. Army Corps of Engineers (USACE) and the National Park Service (NPS) in July 1998, 134,000

cubic yards of sand were dredged from Great Gull Bank located 4 – 6 miles off Assateague Island and placed in low portions of the island to prevent breaching. The MMS and the City of Virginia Beach, VA signed a non-competitive lease agreement in April 1998 authorizing the use of 1.1 million cubic yards of sand from Sandbridge Shoal located in Federal waters to renourish the Sandbridge Beach.

MMS has formed partnerships with the States of New Jersey, Delaware, Maryland, and Virginia to evaluate sand deposits along their coast. The program's goal is to identify potential borrow sites for beach nourishment sand on the Federal OCS when sand from other sources may be insufficient for future requirements. The ongoing work includes geophysical surveys, vibracore sampling, archaeological surveys, benthic biological sampling, water analyses, and wave modeling.

1.1 Report Objectives and Organization

1.1.1 Purpose and Need

The purpose of this Environmental Report (ER) is to assess the possible environmental consequences and mitigation associated with dredging, transporting, and placing Federal OCS sand on beaches requiring nourishment along the U.S. mid-Atlantic coast from northern New Jersey to the Virginia/North Carolina border. The ER will cover all identified and potential OCS borrow sites.

The ER will enable the MMS to make environmentally sound decisions and issue non-competitive agreements in a timely manner. The information provided in the ER along with site-specific biological and physical information collected under MMS's Environmental Studies Program will be used during the preparation of required National Environmental Policy Act (NEPA) documents to assess requests for noncompetitive leases for planned and emergency nourishment projects. This document will help to facilitate the NEPA process when specific replenishment projects are proposed. The information and analyses could also be used in the preparation of NEPA documents to examine impacts associated with possible competitive sales for offshore sand and gravel deposits which lie within Federal waters.

1.1.2 Historical Storm Damage

Coastal storms that inflict the most damage along the mid-Atlantic coast are typically referred to as "nor'easters". These storms are associated with low-pressure disturbances which produce strong northeasterly winds and damaging waves along the shoreline. These storms can produce damaging waves for a duration of up to several days; they occur most frequently between December and April. Hurricanes and tropical storms also impact the project area but less frequently.

Over the past decade, coastal storms traversing up the east coast of the U.S. have caused severe beach erosion and economic losses. Oceanfront and coastal homes, businesses, and roads have been undermined and flooded; even residences and businesses several blocks from the beaches have been severely damaged as high storm waters have carried away vast amounts of beach sand and breached dune systems which usually prevent this type of impact. City and town infrastructure such as water and sewer lines have also been adversely affected and contaminated by sea water intrusion.

The winters of 1991 (October "Halloween Storm") and 1992 (January and December) brought three significant coastal storms which caused extensive damage along the mid-Atlantic coast, especially the Avalon/Townsends Inlet area of New Jersey (Ramsey and Talley 1992; Ramsey *et al.* 1993). Recently, in the fall/winter seasons of 1997 - 1998, noreasters caused unprecedented damage to coastal resort towns in Virginia (Sandbridge), Maryland (Assateague, Ocean City), Delaware (Rehoboth, Bethany Beaches), and New Jersey (beaches in Ocean, Monmouth, Atlantic, and Cape May counties) (Ramsey *et al.* 1998). Federal disaster regulators released damage estimates of $1.7 million for Rehoboth and Bethany Beaches after the passage of a severe storm in February 1998. As a result of the same storm, preliminary damage estimates for Ocean County, New Jersey were around $4.5 million and expected to rise to as much as $12 million after the assessment is completed.

1.1.3 Report Organization

The report provides information on the existing conditions (Chapter 2) and potential impacts (Chapter 3) from dredging and placement of sand on the physical, biological, and socioeconomic environments within the study area. The topics are addressed separately for the continental shelf and beach areas. The report also provides a discussion of potential mitigation measures to avoid and minimize potential impacts in Chapter 4. Chapter 5 provides a discussion of the relevant Federal and state laws and regulations. Chapter 6 provides a list of references used to compile the report. Appendix A provides a discussion of the potential impacts from sand and gravel mining for aggregate within the study area.

1.2 Study Area Description

1.2.1 Region

The study area covered in this report is comprised of the OCS which extends from 3 miles offshore to a water depth of approximately 200 meters (approximately 50-150 km from shore). It extends from northern New Jersey (tip of Sandy Hook) to the Virginia/North Carolina border (Figure 1-1). The study area also includes the oceanfront sand beaches of New Jersey, Delaware, Maryland, and Virginia. The continental shelf areas have the potential to be impacted by the dredging of sand and the sand beaches have the potential to be impacted by the placement of sand on the beach.

1.2.2 Identified Borrow Areas

As described in detail in Section 2.2.1 and depicted on figures contained therein, specific subsurface features on the OCS are potential sources of large quantities of sand. These include paleoshorelines, shoals, filled channels, and shoal retreat massifs or retreat paths of estuary mouths. To date, specific borrow areas have been identified by the individual states within the study area and are described in more detail below. Considering the economics and mechanics of sand dredging and placement on the beach, these sites are necessarily near the 3-mile limit.

New Jersey

Working in cooperation with MMS, the New Jersey Geological Survey (NJGS) has identified seven potential sand resource areas in Federal waters:

- Areas A & B - offshore of Townsends Inlet. Approximately 120,000,000 cubic yards of sand located in two shoals
- Areas C & D - offshore of Long Beach Island. A small number of low-relief, wide shoal features. Sand is probably of lower quality, mixed with muds and gravel.
- Area E - offshore Barnget Inlet. Older coastal plain sediments inclined seaward, with an overlying veneer and discrete caps of sand.

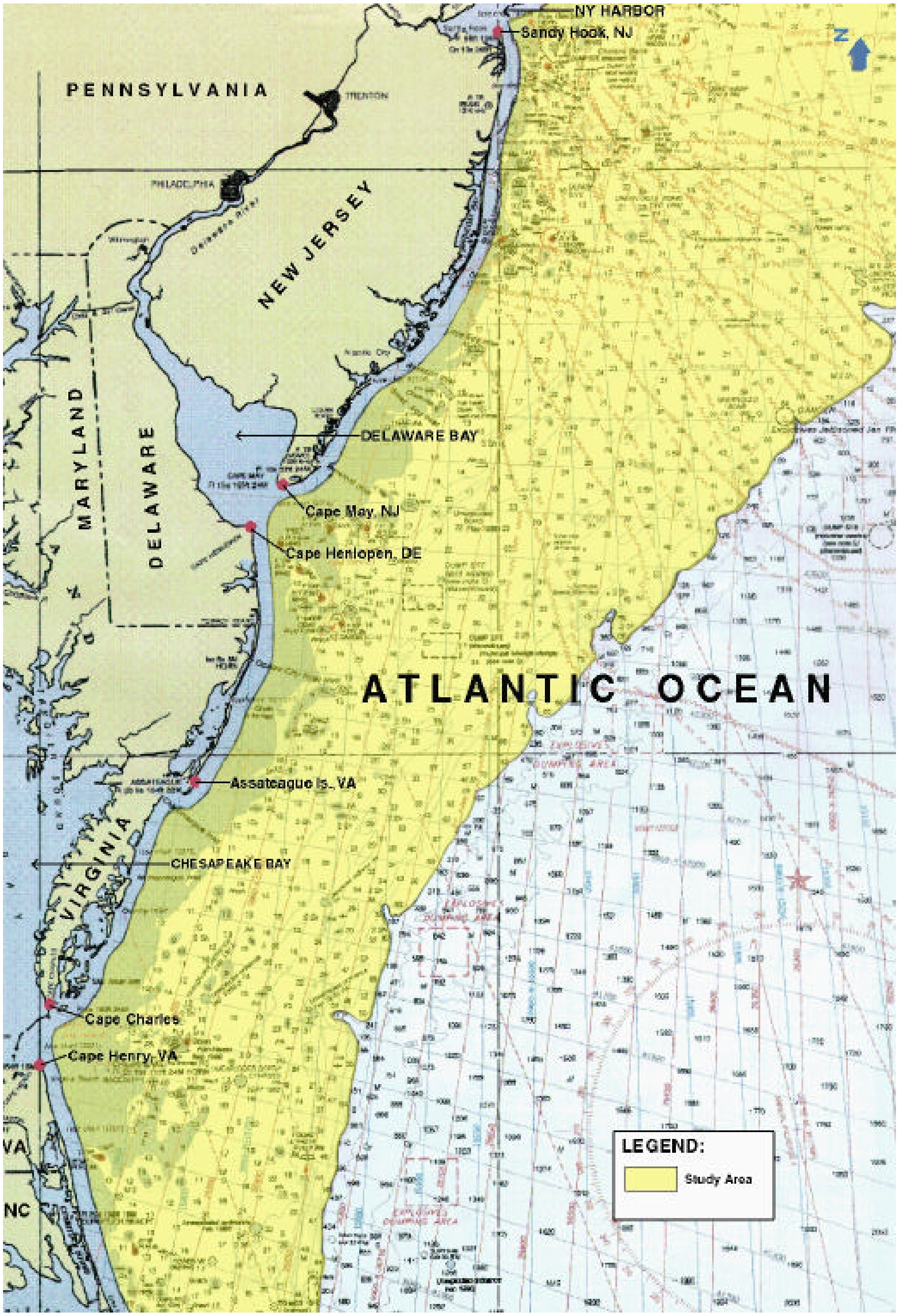


Figure 1-1. Study Area Within the Mid-Atlantic Bight of the United States
Reference NOAA Chart 13003 Depth Units: Fathoms

- Area F - offshore of Mantoloking. It is in a setting similar to Area E.

- Area G - offshore Atlantic City. Shoal field that extends across the State/Federal line, extensive deposits.

Delaware

The Delaware Geological Survey (DGS) has been working with MMS on a multiyear program to identify suitable sand deposits in Federal waters off the coast of Delaware for beach restoration. The program has identified large bodies of sand off Indian River Inlet as well as Fenwick Shoal, located about 10 km east of the Maryland-Delaware border. The sand bodies contain approximately 46 million cubic yards and 34.5 million cubic yards, respectively, of usable sand resources (Ramsey and McKenna 1999a).

Maryland

In a similar cooperative program with MMS, the Maryland Geological Survey (MGS) has determined that significant sand resources are present in the linear, shore-detached sand ridges or shoals located off the Maryland shoreline. The MGS has delimited three shoal fields as potential sand resource areas for beach nourishment. The sand shoals beyond the 3-mile limit in Federal waters are detached ridges (i.e., not attached to the shoreface).

- Shoal Field I is located approximately 8 km east of Fenwick Island south of the Maryland-Delaware border, north of the Ocean City Inlet.

- Shoal Field II is located south of Shoal Field I approximately 6 km east of the Ocean City Inlet.

- Shoal Field III is located south of Shoal Field II approximately 18 km south of the Ocean City Inlet.

Virginia

Significant sand sources are located in the Sandbridge Shoal which is located on a nearshore ridge formation in Federal waters offshore of the City of Virginia Beach. Sandbridge Shoal contains sand reserves estimated to be as much as 40 million cubic yards. Material from this shoal has been used for local beach restoration and hurricane projects twice.

1.3 MMS and Federal/State Agency Coordination and Review

Coordination between the MMS and Federal and state agencies has been ongoing since the inception of the project. A kickoff meeting was held on November 3, 1998 at the University of Delaware, with representatives from the USACE, Philadelphia, Baltimore, and Norfolk Districts and the states of New Jersey, Delaware, Maryland and Virginia in attendance. In April 1999, the MMS and USACE signed a Memorandum of Agreement (MOA) establishing procedures for coordination and cooperation with respect to the use of OCS sand, gravel and shell resources for USACE-authorized shore protection projects (Appendix D). A review and comments on the report outline and preliminary draft sections of the report followed. A second meeting was held on May 5, 1999 at the Virginia Institute of Marine Science (VIMS), in Gloucester Point, Virginia. In addition, the participants have reviewed and commented on drafts of the report.

2.0 EXISTING ENVIRONMENTAL CONDITIONS

2.1 Introduction

This chapter discusses the current conditions within the study area which encompasses the OCS and beach areas from northern New Jersey (Sandy Hook) to the Virginia/North Carolina border. Because of differences in the physical and biological conditions of the continental shelf and beach areas, the two areas are described separately.

This section describes the physical attributes of the study area, including the morphologic features which are potential sources of sand, geology, meteorological and oceanographic processes, and water/sediment chemistry. Each of the factors is important in determining the location of potential sand borrow areas and in the evaluation of potential impacts from the dredging/extraction operation and placement on the beach.

Because the systems of units varied by study, units are reported as found in each study with a conversion to inch-pound or metric, as needed. A conversion table is also provided at the beginning of the report.

2.2 Continental Shelf

The continental margin is the ocean floor between the shoreline and the abyssal ocean floor (Bates and Jackson, 1980, American Geological Institute *Glossary of Geology*). It consists of several physiographic provinces. Along the Atlantic coast of the United States, these provinces are the continental shelf, continental slope, and continental rise (Figure 2-1). The shelf is characterized by a very gentle slope of 0.1^{o} while the continental slope is characterized by a relatively steep slope of 3^{o} to 6^{o}. The demarcation between the continental shelf and the continental slope is the shelf edge. An abrupt change in slope, marking the boundary between the continental shelf and continental slope, is the shelf break. Where there is no noticeable continental slope, a depth of 200 meters marks the shelf edge. The continental rise is a gentle incline with slopes of 1:40 to 1:2000. The width and depth of the shelf decrease south of New Jersey. Off New Jersey, the shelf is about 150 kilometers wide and extends to a depth of about 160 meters (Milliman 1972). Off Cape Hatteras, the shelf is 23 kilometers wide and extends to a depth of 55 meters (Uchupi 1968).

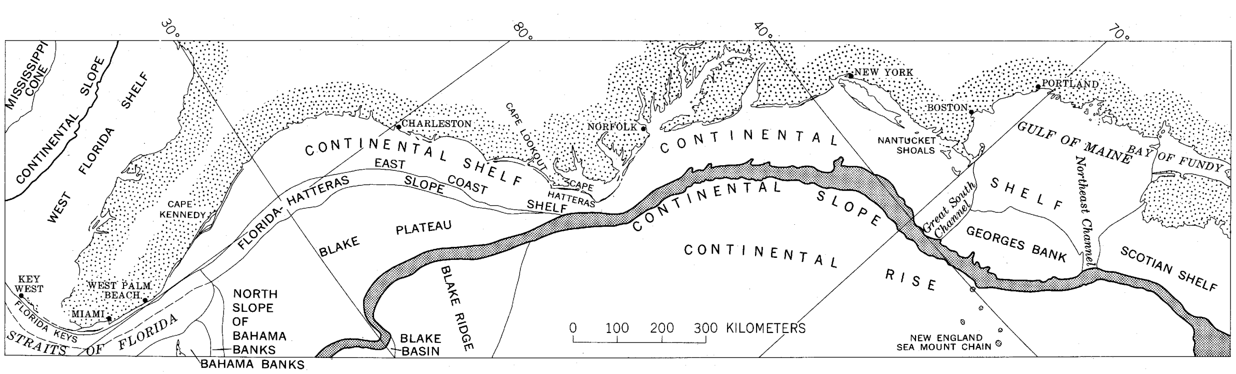


Figure 2-1. Physiographic provinces of the Atlantic continental margin from Nova Scotia to Florida Keys (from Uchupi 1968).

As described in Section 1.2.1, for the purposes of this report the OCS consists of submerged Federal lands on the continental shelf that lie seaward of State-jurisdictional offshore waters to a depth of approximately 200 meters. The seaward limit of State offshore lands is 3 nautical miles. The study area considered in this report consists of that portion of the OCS from the New York Bight area southward to offshore Virginia Beach (Figure

1-1).

2.2.1 General Continental Shelf Morphology

Between Norfolk, Virginia and Nantucket Island, Massachusetts the continental shelf is bounded by a slope. The shelf break is at a depth of 120 to 160 meters (Uchupi 1968). Topographic and subsurface features on the continental shelf of the study area (paleoshorelines; shoals; filled channels; retreat paths of estuary mouths) are potential sources of large quantities of sand (Duane and Stubblefield 1988).

2.2.1.1 Paleoshorelines

Sea level has been lower than at present during the Pleistocene and Holocene epochs (within the last 1.6 million years) due to periods of glaciation. Much of today's continental shelf was subaerial and the positions of earlier shorelines lie seaward of the present shoreline. Old shorelines have been recognized on the shelf (Emery and Uchupi 1972; Duane and Stubblefield 1988). The topographic expression of these paleoshorelines are terraces and shore parallel breaks in slope produced by stillstands of sea level. They extend hundreds of kilometers. Paleoshorelines are located near the shelf edge in 120 to 160 meters of water (Nichols and Franklin Shores) and shallower in 60 to 80 meters (Block Island Shore) (Figures 2-2, 2-3).

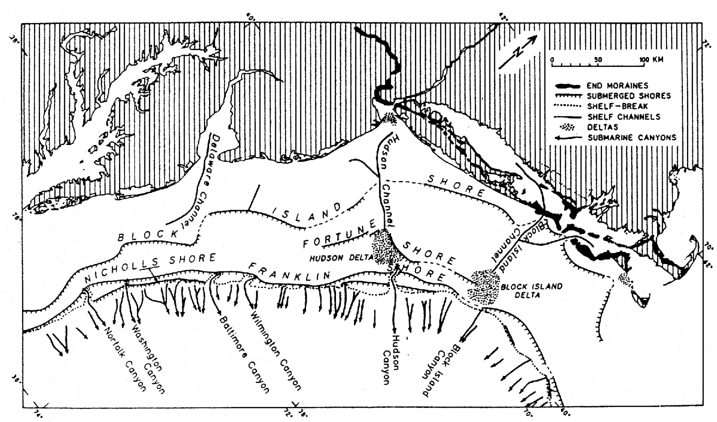


Figure 2-2. Submerged end moraines, river channels, shorelines, and deltas of Hatteras-Cape Cod Shelf (from Emery and Uchupi 1972).

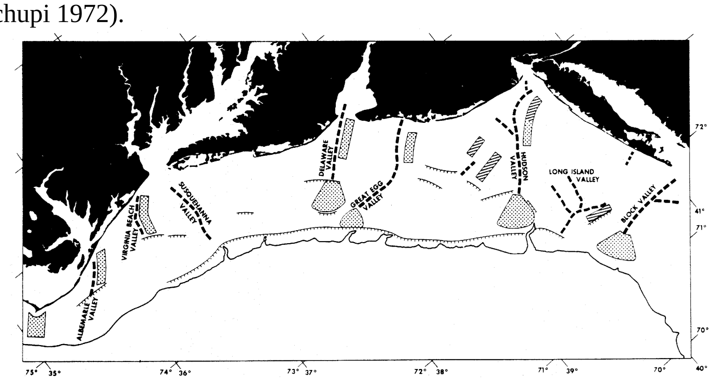


Figure 2-3. Major morphological features of the Mid-Atlantic Bight. Dashed lines are shelf valleys, hatched lines are scarps. Stippled areas are highs of probable constructional origin including shoal retreat massifs and still-stand deltas. Diagonally ruled areas are of probable erosional origin (from Swift *et al.* 1972).

2.2.1.2 Shoals

Linear shoals form the ridge-and-swale topography that characterizes much of the Mid-Atlantic continental shelf

(Figure 2-4). On the inner shelf, ridge spacing ranges between x and y are 1.6 to 6 kilometers, wave length is approximately 2 kilometers, amplitude ranges 2 to 10 meters, and lengths range 9 to 56 kilometers (Duane and Stubblefield 1988). Nearshore, shoals are aligned at angles ranging from 20 to 30 degrees with the coastline. The ridge-and-swale topography extends to the deeper shelf where linear ridges tend to be coast parallel. Shoals associated with inlets and capes on the Mid-Atlantic shelf are arcuate (*i.e.*, Duane *et al*. 1972). In the study area, arcuate shoals are associated with the entrances to Delaware Bay and Chesapeake Bay.

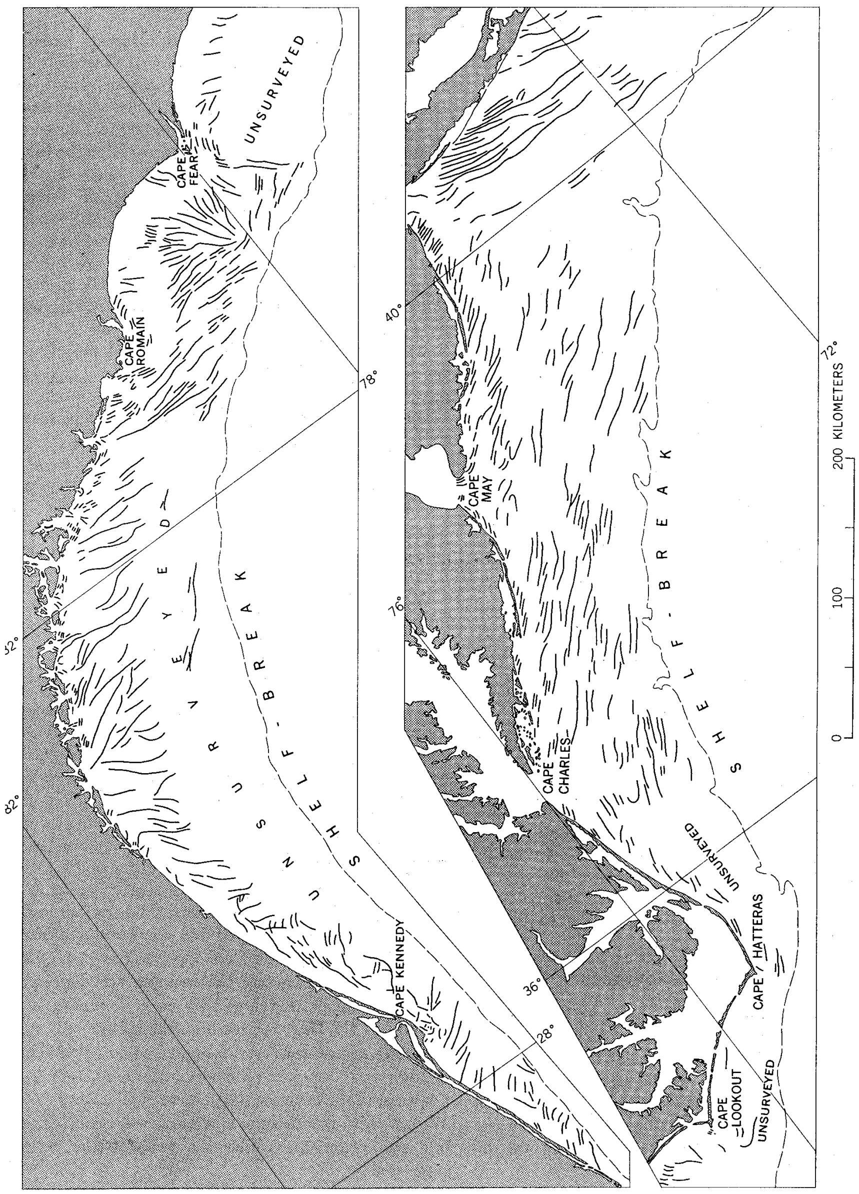


Figure 2-4. Sand swells on continental shelf from New York to Cape Kennedy. Curved lines indicate crests of sand swells (from Uchupi 1968).

2.2.1.3 Filled Channels

Numerous surface channels, or valleys, traverse the shelf (Emery and Uchupi 1972; Swift *et al*. 1972; Duane and Stubblefield 1988). The major cross shelf topographic channels in the study area are Hudson Valley, Great Egg

Valley, Delaware Valley, Susquehanna Valley, and Virginia Beach Valley (Figure 2-3). Major valleys are several kilometers wide and are filled with tens of meters of sediment. Deltaic features are located at the seaward ends of cross shelf valleys (Figure 2-3) (Emery and Uchupi 1972; Swift *et al*. 1972, 1980). Buried paleochannel valley fills in the subsurface also occur in the study area (Sheridan *et al*. 1974; Knebel *et al*. 1979; Field 1980; Swift *et al*. 1980) (Figure 2-5).

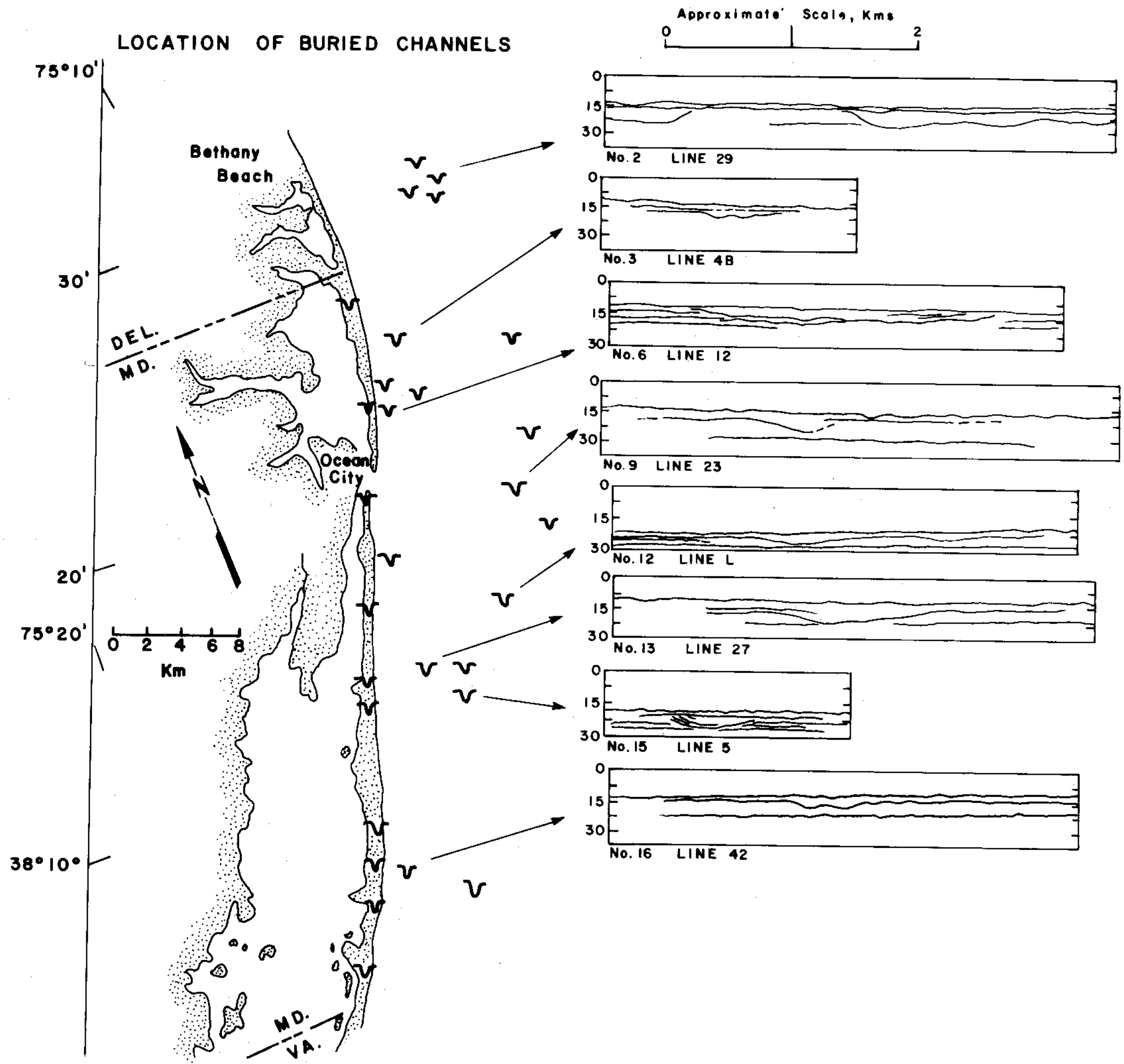


Figure 2-5. Locations and examples of interpreted acoustic profiles of buried channels on the inner shelf between Bethany Beach, DE and the MD-VA line (from Field 1980).

2.2.1.4 Shoal Retreat Massifs

Broad areas with topographic relief that are related to former positions of estuary mouths are termed shoal retreat massifs (Figure 2-3) (Swift *et al*. 1972; Duane and Stubblefield 1988). These are cumulative estuary mouth deposits left on the shelf as sea level rose and estuary positions "retreated" landward. Where retreat paths followed subaerial river valleys, the results are shelf valleys partially or completely filled with estuarine sediments (Swift *et al*. 1980).

2.2.2 Geological Setting

The geology of the study area has been summarized below from numerous articles found in Sheridan and Grow (1988). These are: Grow and Sheridan 1988; Grow *et al*. 1988; Klitgord *et al*. 1988; Manspeizer and Cousminer 1988; Olsson *et al*. 1988; Poag and Valentine 1988; Riggs and Belknap 1988. A geologic time scale is provided in Table 2-1 below.

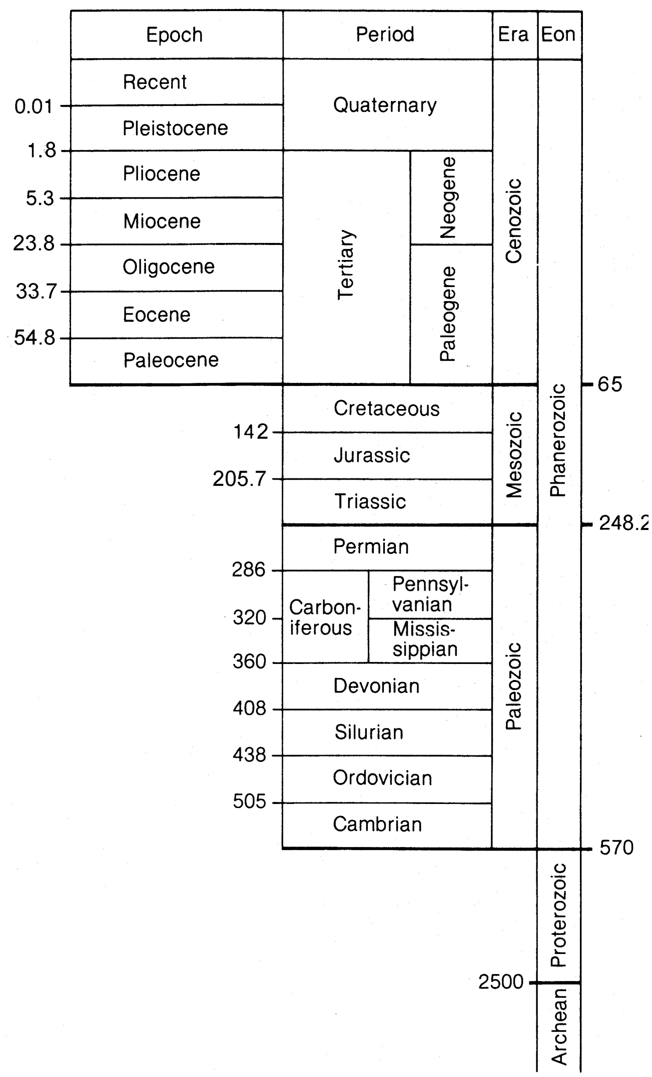


Table 2-1. Geologic time scale in million years before present. Some dates are uncertain (from Press and Siever 1986; Gradstein and Ogg 1996).

2.2.2.1 Pre-Quaternary Geology

The existing U.S. Atlantic continental margin developed with the incipient formation of the central North Atlantic

Ocean by extensional rifting (Late Triassic - Early Jurassic) (230-187 million years before present) and separation by seafloor spreading (Middle Jurassic) (187-163 million years before present) of the African and North American plates. The depositional sequences beneath the study area are related to bathymetric variations in the Baltimore Canyon Trough, the major sedimentary basin underlying the continental shelf of the study area (Figure 2-6). Sediments deposited in this basin form a seaward thickening wedge of sedimentary units that overlie the crystalline basement. The western margin of the Baltimore Canyon Trough crops out onshore as coastal plain deposits. Depositional sequences in the trough have been largely controlled by cycles of sea level change. Unconformities, or stratigraphic gaps, representing periods of erosion and nondeposition during lowered sea levels punctuate the sedimentary sequence.

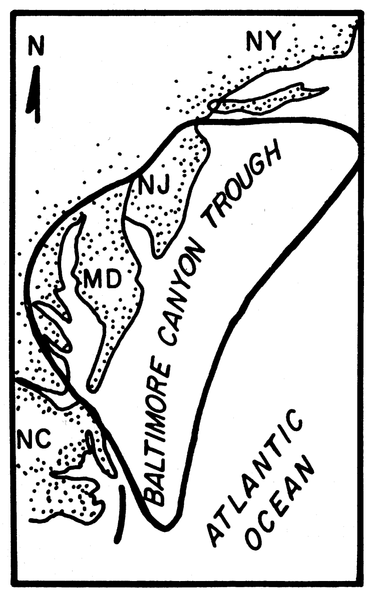


Figure 2-6. Baltimore Canyon Trough underlying the mid-Atlantic continental shelf (from Plate 3, Sheridan and Grow 1988).

The strata that overlie the basement consist mostly of Mesozoic (248.2-65 million years before present) and Cenozoic (65 million years before present to present) terrigenous siliciclastics and marine carbonates with some volcanic units. Onshore cores beneath the coastal plain reach basement rocks that are Paleozoic (570-248.2 million years before present) granitic and metasedimentary rocks. The deepest subbasin of the Baltimore Canyon Trough lies offshore New Jersey and contains at least 18 kilometers of sedimentary rocks.

2.2.2.2 Quaternary Geology

The Quaternary (1.8 million years ago to present) history of the project area (Pleistocene and Holocene epochs) is dominated by sedimentary responses to numerous episodes of glaciation. The study area lies south of the maximum advance of Pleistocene glaciation. Although nonglaciated, it was still affected by the sea level fluctuations associated with glacial events. The Pleistocene record on most of the inner and middle shelf is thin and poorly preserved, largely due to the landward migration of a littoral zone of erosion as sea level rose. Pleistocene units thicken to the outer shelf. The maximum low stand of sea level approximately 18,000 years ago, associated with the most recent glaciation (Wisconsinian stage of the Pleistocene), was near the shelf edge. The subsequent Holocene rise in sea level (Holocene transgression) has led to the present sedimentary environment on the continental shelf and at the shoreline. The rate of sea level rise, sediment supply, and flow regime have interacted to produce the conditions that have led to the development of the morphologic features described in Section 2.2.1.

2.2.2.3 Potential Sand Resources for Beach Nourishment

The continental shelf features described in Section 2.2.1 as potential sources of sand formed during the Quaternary Period. Shelf valleys were incised during low stands of sea level; paleoshorelines represent low stands; and channels were backfilled to produce paleochannel fills. Other features were initiated and have developed during the Holocene transgression. Topographic features are undergoing erosion and deposition today by shoreface retreat at the coastline and under the present hydrologic regime on the shelf. These features are viable sources of sand for the purpose of beach nourishment, however, only if they provide large enough quantities of sediment with suitable grain size and sorting properties. For example, paleodrainage valleys identified by Sheridan *et al.* (1974) on the continental shelf off Delaware are filled with lagoonal muds. These sediments are not suitable as beach fill.

Brobst and Pratt (1973) distinguish between *reserves* and *resources* based on economic availability. Reserves are known, identified deposits of mineral-bearing rock from which the mineral or minerals can be extracted profitably with existing technology and under present economic conditions. On the other hand, they define resources as including reserves and other mineral deposits that may eventually become available - either known deposits that are not economically or technologically recoverable at present, or unknown deposits that may be inferred to exist but have not yet been discovered.

MMS (1994) goes on to broadly classify sand and gravel resources as *identified* or *undiscovered*. *Identified* resources are deposits whose locations and characteristics are known or estimated from geologic data within or close to the deposits whereas *undiscovered* resources are postulated from indirect geologic evidence. The existing grain size distribution of surficial sediments blanketing the continental shelf has been generalized and mapped by the MMS (Map 2, MMS 1994). Using an average thickness of 5 meters, MMS has calculated a total sand resource on the Mid-Atlantic shelf (*i.e.,* identified and undiscovered resources) of 400 billion cubic meters (523 billion cubic yards) (MMS 1994). The identified sand resource volume calculated by MMS (1994) for the area mapped as more than 75% medium to coarse sand is 340 billion cubic meters (445 billion cubic yards).

Identified and undiscovered resource categories are further classified as measured, indicated, inferred, hypothetical, and speculative (MMS 1994) (Figure 2-7). *Measured* resources are identified resources whose character is well established by closely-spaced sampling and geophysical data. *Indicated* resources are identified resources based on less closely spaced sampling data. *Inferred* resources are identified resources based on the assumption of continuity beyond deposits of measured and/or indicated resources for which there is some geologic evidence. *Hypothetical* resources are undiscovered resources that could occur on trend with or close to identified resources. *Speculative* resources are undiscovered resources that might occur in areas where sand and gravel were not thought to exist. MMS (1994) calculated a hypothetical sand resource (fine, silty sand landward of the 200 meter bathymetric contour) of 59 billion cubic meters (77 billion cubic yards).

Volume calculations of sand resources on the Mid-Atlantic shelf are subject to errors stemming from averaging sand thicknesses from shelf features with varying dimensions. Cores taken on the Mid-Atlantic continental shelf show actual surficial sand thicknesses ranging from less than one meter to as much as 40 meters, averaging 3 to 6 meters (Duane and Stubblefield 1988; MMS 1994).

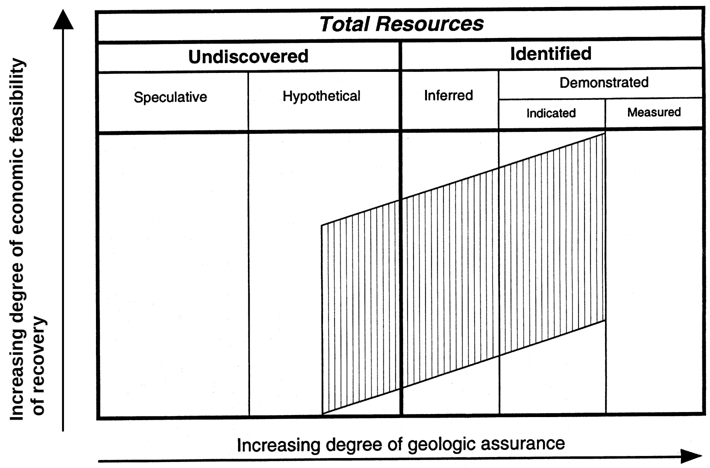


Figure 2-7. Mineral resource classification system used by MMS (from MMS 1994).

Numerous workers have estimated local and regional resources by estimating surface areas and surficial sediment thicknesses of blanket sands, sand shoals and buried channels. These are summarized in Table 2-2.

2.2.2.4 New Jersey Continental Shelf

A. Regional Sediment Characteristics

1. Grain Size

a. Surface

General mapping of continental shelf sediments indicates that surficial sediments off New Jersey consist primarily of detrital sands with varying mixtures of silt or gravel (Milliman 1972; Hollister 1973; Schlee 1973; MMS 1994). Inside the state three mile limit south of Asbury Park, offshore sediments consist of less than 75 percent sand (very fine and fine grained sand) mixed with silt (MMS 1994). Similar sands are found as a northwest-southeast trending finger extending into federal waters from the New York Bight (Map 2, MMS 1994). Another finger extends into federal waters off Barnegat Inlet. Gravelly sands (10 to 49 percent gravel) extend offshore from the federal limit as far as 75 km, particularly north of Beach Haven Inlet to Asbury Park. An area comprised of 50 percent or greater gravel occurs off Island Beach State Park. Elsewhere, surface sediments are more than 75 percent medium to coarse sands.

More detailed studies of offshore sediment grain size parameters have been conducted off the southern New Jersey coastline (Donahue *et al.* 1966; Frank and Friedman 1973; Stahl *et al.* 1974; Stubblefield *et al.* 1974, 1975, 1983, 1984; Smith 1996).

The findings of Frank and Friedman (1973) demonstrate the textural variability of surface sediments on the New Jersey shelf. Across the shelf between Ship Bottom and Brigantine out to waters 100 fathoms deep, there is a patchy and irregular distribution of sediment grain sizes (Figure 2-8). The mean grain size is predominantly medium sand. However, finer grained sand with little biogenic constituents is found in depths less than five fathoms and in patches at 20 and 36 fathoms. Fine grained sand also is found near the shelf edge where the contribution of planktonic foraminifera to the sediment increases. Between five and

Table 2-2.
Estimates of Sand Resources on the U.S. Atlantic Continental Shelf

Site	Volume (m^3)	Annual Beach Fill Requirements** (m^3)	Citation
MID-ATLANTIC PROVINCE	Total: $1.3x10^{10}$		
South Shore Long Island (area: $2x10^3$ km^2)	$6.0x10^9$	$4.7x10^7$	2
Inner Long Island Shelf*	$7.0x10^6$		3
New Jersey Shelf*	$1.5x10^7$		3
Delaware Shelf*	$1.4x10^7$		3
Inner N.Y. Bight			
Rockaway Beach	$7.9x10^8$	$3.5x10^5$	4
Sandy Hook to Mommouth, NJ	$7.8x10^8$	$1.8x10^5$	4
Central New Jersey Shelf			
Barnegat to Towsend Inlet	$1.7x10^8$		5
Sandy Hook, NJ	$3.6x10^8$		1
Manasquan, NJ	$4.6x10^7$		1
Barnegat, NJ	$3.4x10^8$		
Little Egg Harbor, NJ	$1.4x10^8$		1
Cape May, NJ	$1.4x10^9$		1
Delmarva Peninsula	$1.7x10^9$		6
Thimble Shoals in Chesapeake Bay (sand and gravel)	$1.5x10^7$		7
Thimble Shoals in Chesapeake Bay (fine sand)	$1.4x10^9$		7
Townsends Inlet, NJ	$8.57 x 10^7$		8
Townsends Inlet, NJ	$9.55 x 10^7$		9
Cape May, NJ	$1.08 x 10^9$		9,10
Indian River Inlet, DE	$6.9 x 10^7$		11
Fenwick Shoal, DE	$4.6 x 10^7$		11
Shoal Field I, Northern MD	$1.75 x 10^8$		12
Shoal Field II, Central MD	$3.84 x 10^8$		13
Shoal Field III, Southern MD	$3.36 x 10^8$		14
Sandbridge Shoal, VA	$8 x 10^7$		15
Sandbridge Shoal, VA	$3.0 x 10^7$		16
Channel fill, Virginia Beach, VA	$3 x 10^6$		16

*10 km from shore to 50 m of water depth.
**data listed where given.

1. From Duane (1969)
2. From Williams (1976)
3. From Schlee and Sanko (1975)
4. From Williams and Duane (1974)
5. From Meisburger and Williams (1982)
6. From Field (1979)
7. From Meisburger (1972)
8. Smith (1996)
9. Uptegrove *et al.* (1997)
10. Meisburger and Williams (1980)
11. Delaware Geological Survey
12. Conkwright and Gast (1994a)
13. Conkwright and Gast (1994b)
14. Conkwright and Gast (1995)
15. Kimball *et al.* (1991)
16. Hardaway *et al.* (1995)

Source: from Duane and Stubblefield 1988, and The Louis Berger Group, Inc. 1999.

18 fathoms, coarse sand associated with the southern edge of a gravel deposit reported by Schlee (1964) was encountered.

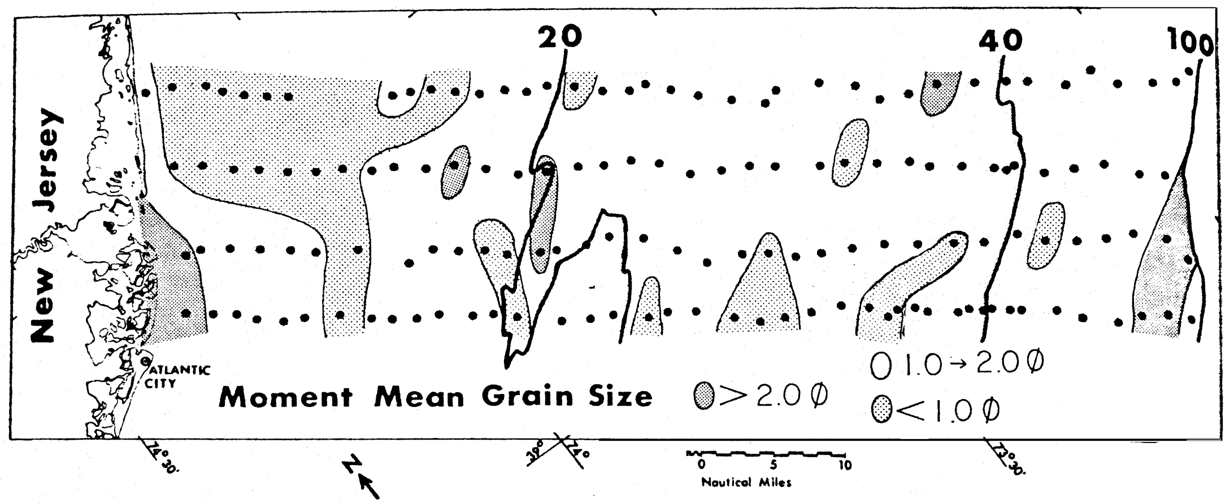


Figure 2-8. Mean grain size of offshore sediments off southern New Jersey (from Frank and Friedman 1973). Depth contours are in fathoms.

Shelf sediments along a northwest-southeast trending transect offshore Beach Haven are characterized with a median grain size of 0.2 to 0.5 mm (fine to medium grained sand) (Donahue *et al.* 1966) (Figures 2-9 and 2-10).

Several studies have focused on ridge and swale features on the shoal retreat massif north of Great Egg Valley between Beach Haven Inlet and Absecon Inlet (Stahl *et al.* 1974; Stubblefield *et al.* 1974, 1975, 1983, 1984) (Figures 2-11 and 2-12). Grain sizes and degrees of sorting are variable across these features. Figure 2-13 illustrates grain size variations across sand ridges.

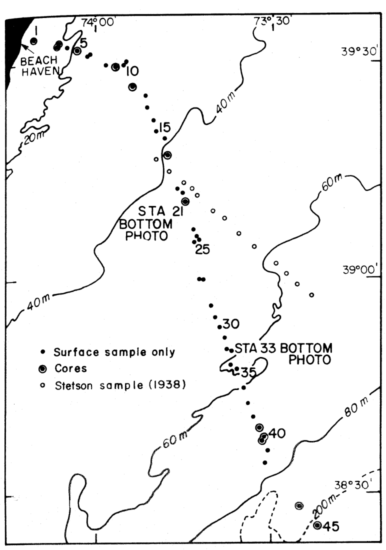


Figure 2-9. Sample sediment locations (from Donahue *et al.* 1966).

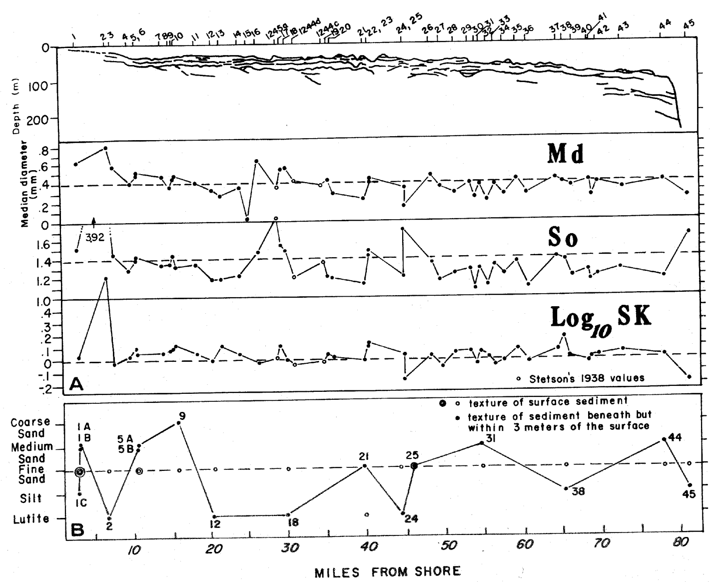


Figure 2-10. A. Median diameter (Md), sorting (So), and $\log_{10}$ skewness (Sk) for surface sediments.
B. Comparison of sediment texture of tops of cores and at depth (from Donahue *et al* 1966).

The ridge and swale topography of the shelf between Great Egg Harbor Inlet and Hereford Inlet was investigated by Smith (1996) (Figure 2-14). Sediments exposed at the seafloor surface consist of shelf sheet or ridge deposits with grain sizes that range from sandy mud to mud-depleted gravelly sand. These units overlie a regional unconformity. Very coarse sand, gravel, and pebble sediment may be exposed at the surface where erosion in swales exposes units underlying the unconformity.

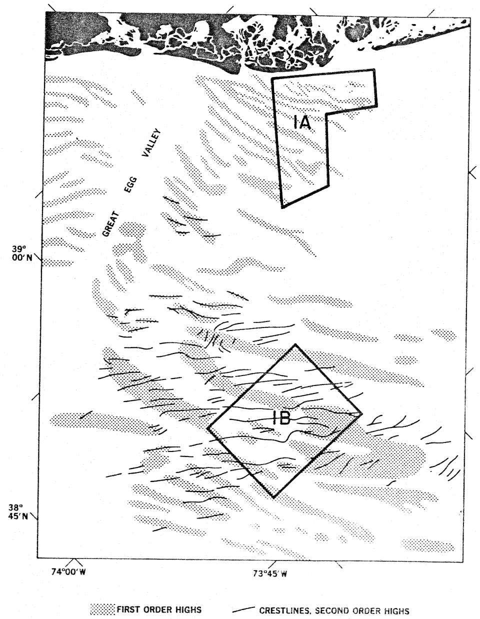


Figure 2-11. Ridge and swale features on shoal retreat massif north of Great Egg Valley (from Stubblefield *et al.* 1974).

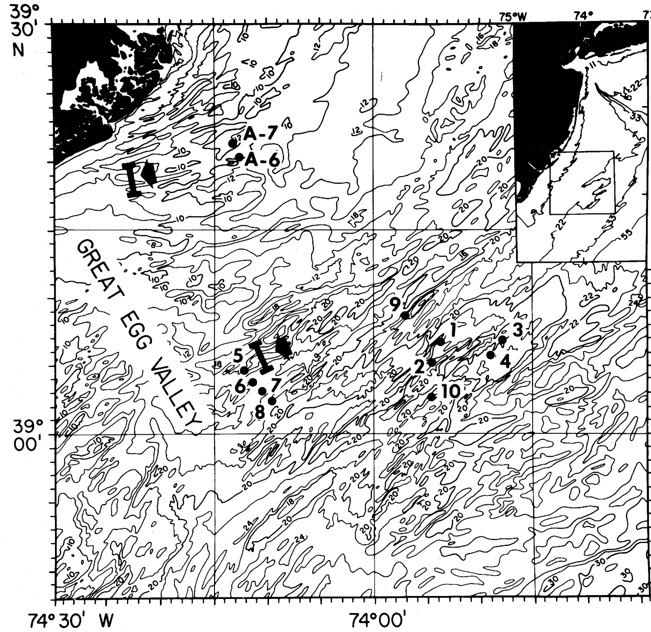


Figure 2-12. Bathymetry on shoal retreat massif north of Great Egg Valley showing vibracore sites and grab sample transects (from Stubblefield *et al.* 1984).

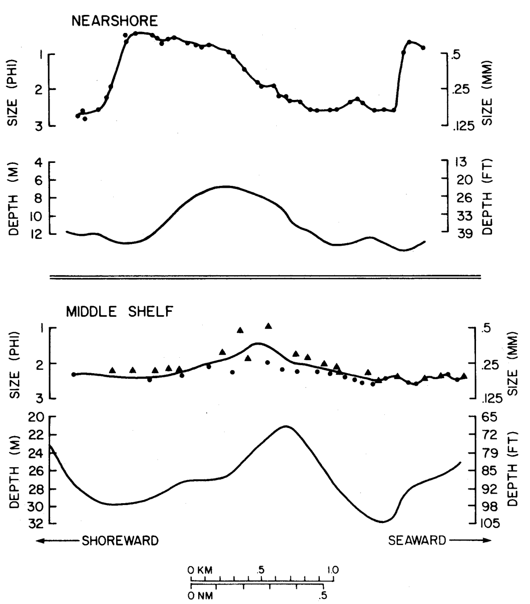


Figure 2-13. Plot of median grain size distribution across nearshore and a mid-shelf ridge transects shown on Figure 2-12 above (from Stubblefield *et al.* 1984).

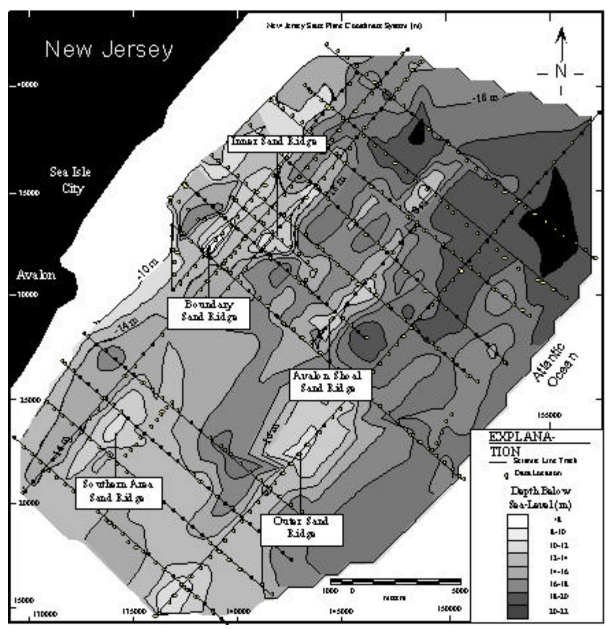


Figure 2-14. Ridge and swale topography of shelf between Great Egg Harbor Inlet and Hereford Inlet (from Smith 1996).

b. Subsurface

Descriptive grain size data of subsurface sediments on the New Jersey shelf are presented in Stahl *et al.* (1974), Stubblefield *et al.* (1975, 1983, 1984) and Smith (1996). Vibracore and seismic analyses have identified mappable lithologic units ranging from muds to gravels of variable thicknesses separated by regional and local unconformable surfaces. Buried paleochannels have been recognized in seismic profiles from nearshore to the shelf edge (Waldner and Hall 1991; Smith 1996; Fulthorpe *et al.* 1999).

2. Composition

a. Mineralogy

The gravel fraction on the New Jersey shelf consists of carbonates (shells and shell fragments), quartz pebbles, and rock fragments (Grosz *et al.* 1989). Terrigenous sands are predominantly quartz and feldspar and are low in carbonates (less than five percent) (Milliman 1972). However, there is a carbonate high off the central New Jersey coast where the carbonate content reaches 25 percent (Figure 2-15).

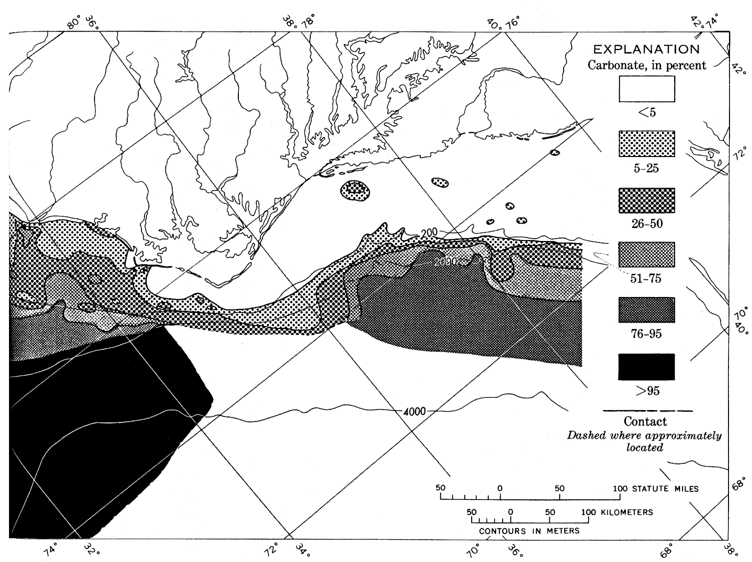


Figure 2-15. Distribution of calcium carbonate in the sand fraction of surface sediment off NJ to SC (from Milliman 1972).

The heavy mineral distribution of shelf sediments off New Jersey at the surface and in the shallow subsurface is variable (Grosz *et al.* 1989; Uptegrove *et al.* 1991). An investigation of 76 surface grabs across the New Jersey shelf (Figure 2-16) identified a heavy mineral assemblage of, in order of decreasing abundance, ilmenite, pyroboles (undifferentiated pyroxene and amphibole), garnet, aluminosilicates (undifferentiated silliminite, kyanite, and andalusite), epidote, staurolite, tourmaline, magnetite, monazite, zircon, and rutile (Grosz *et al.* 1989). Heavy mineral concentrations, on a bulk sample dry weight basis, range from 0.35 to 12.80 weight percent (averaging 3.61%). Overall, the percentage of heavy minerals decreases with depth (Figure 2-17), but magnetite, garnet, pyroboles, and epidote increase. Three coast parallel zones of heavy mineral concentration highs (4%) were discerned: a nearshore zone in waters under 20 meters deep extending from Ocean City to Cape May; a sand ridge system at the 25 to 40 meter depth interval; and the middle portion of the outer shelf (i.e., midway between 40 and 200 meter depths). While sands contain approximately twice the heavy mineral content of gravels, gravels are enriched in ilmenite, zircon, garnet, and staurolite.

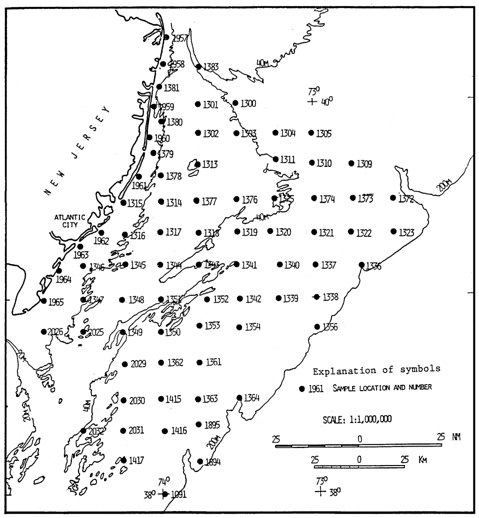


Figure 2-16. Grab sample locations for New Jersey from shelf heavy minerals study (from Grosz *et al.* 1989).

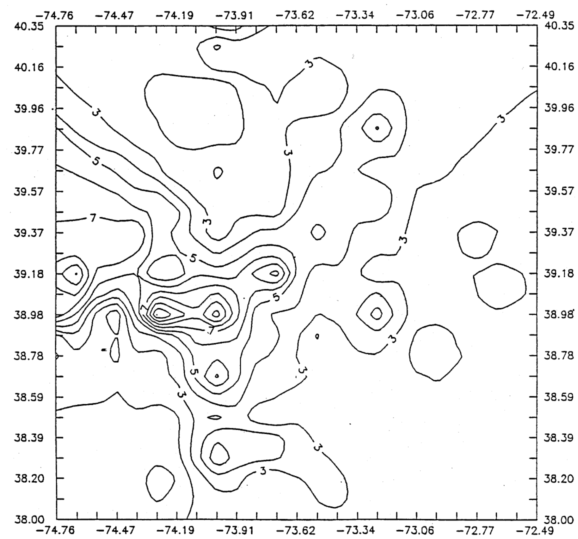


Figure 2-17. Contours (weight percent heavy minerals) of heavy mineral content in area sampled in Figure 2-16 (from Grosz *et al.* 1989).

Heavy mineral analyses have been conducted on samples from 65 vibracores collected from the New Jersey shelf between Absecon and Barnegat Inlets (Uptegrove *et al.* 1991) **(**Figure 2-18). Samples were assessed to a depth of approximately six meters. Heavy mineral content with depth in the cores is variable and a trend (i.e., an increase or decrease with depth) was not identified. The average total heavy mineral content was 1.9 weight percent of the bulk. Ilmenite, leucoxene, rutile, zircon, monazite, and aluminosilicates (silliminite, kyanite, and andalusite) collectively comprise an average of 1.0 weight percent of the bulk sample.

b. Trace Metals

The concentration of nine trace metals (barium, cadmium, chromium, copper, iron, lead, nickel, vanadium, zinc) in surficial sediments is provided in Appendix B. Concentrations generally correlate with the abundance of fine grained sediment and are low compared to average crustal rocks (Bothner 1979). It should be noted that the areas sampled in Bothner (1979) did not include known areas of waste disposal or other anthropogenic point sources of metals on the continental shelf.

The distribution of iron oxide on the continental shelf is presented in Appendix B. The occurrence and degree of iron staining of grains decreases with decreasing grain size (Milliman 1972). The distribution of the iron stained fine sand fraction of continental shelf sediments is shown in Figure 2-19.

B. Identified Offshore Sand Resources

Meisburger and Williams (1980, 1982) identified potential sand resources on the continental shelf off central and southern New Jersey. The sites they identified are located in state and federal waters and are indicated on Figures 2-20a and 2-20b as BI and CM sites. Currently, NJGS is leading a cooperative effort with MMS to collect and assess data on potential sand resources in Federal waters (Uptegrove *et al.* 1997).

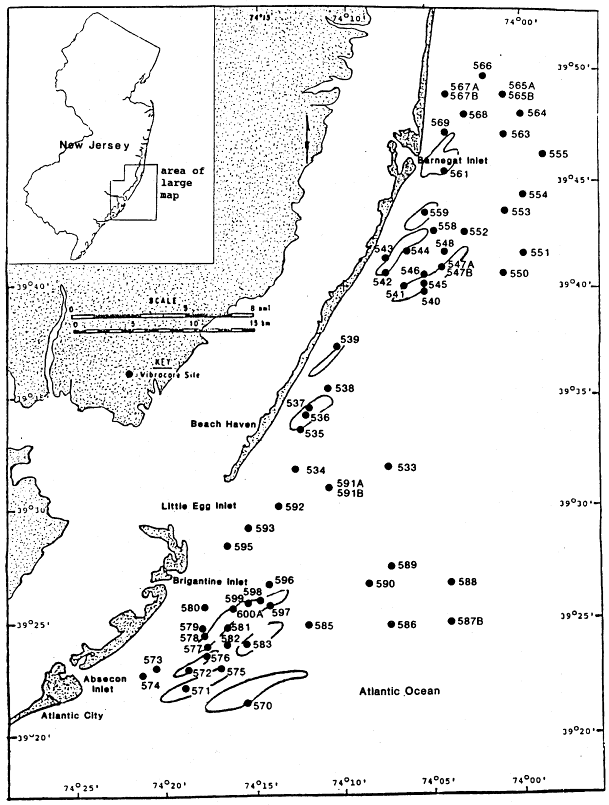


Figure 2-18. Vibracore sample locations for New Jersey shelf mineralogic study (from Uptegrove *et al.* 1991, after Meisberger and Williams 1982).

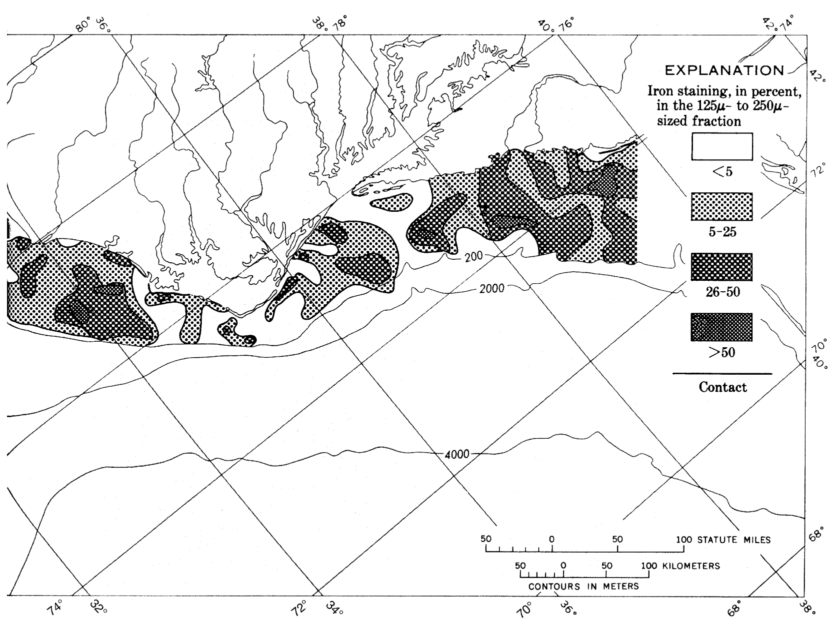


Figure 2-19. Distribution of iron-stained surface sediment of the 125-250 micron sand fraction off NJ to SC (from Milliman 1972).

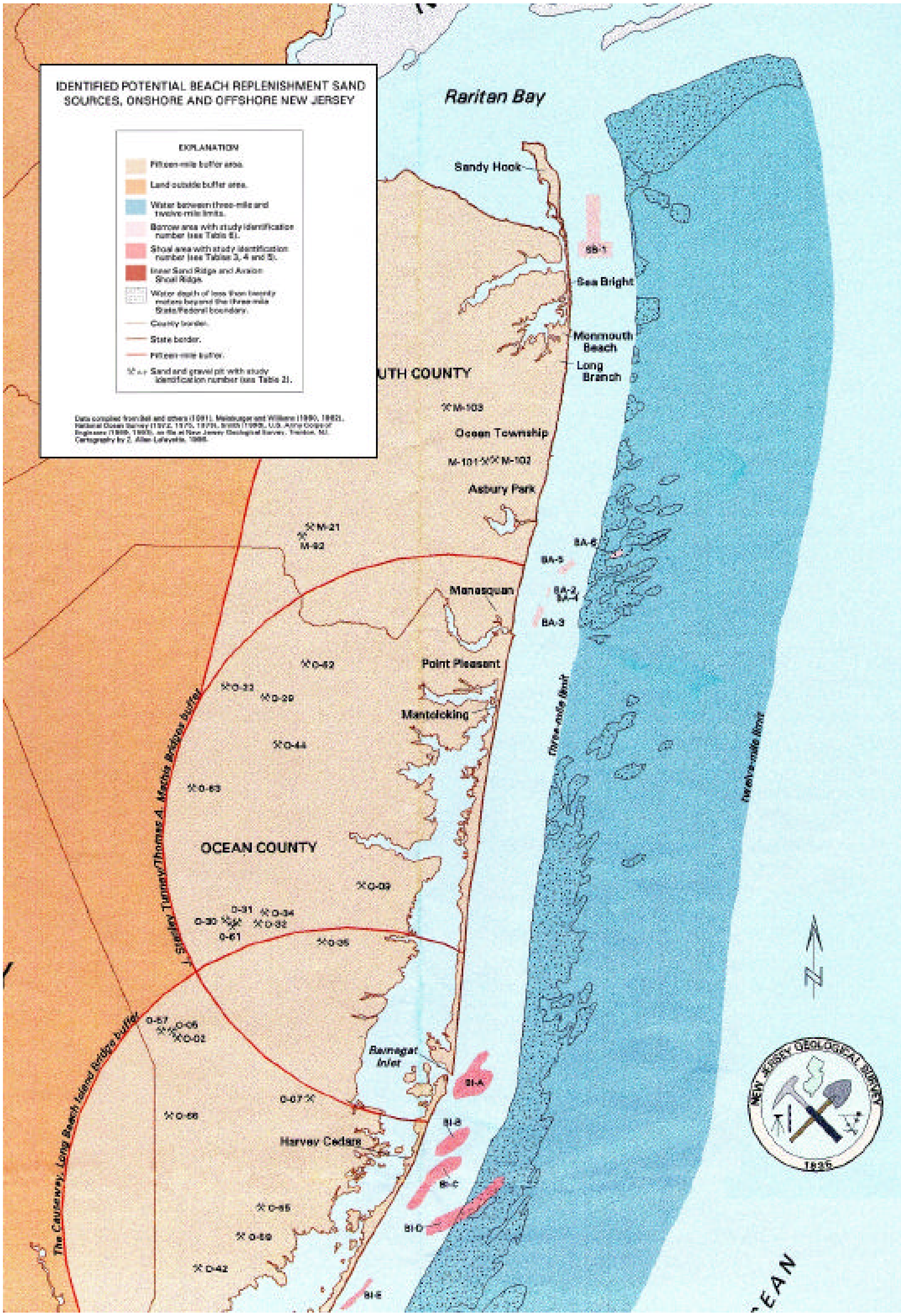


Figure 2-20a. Identified potential beach replenishment sand sources, onshore and offshore New Jersey (from Uptegrove *et al.* 1997).

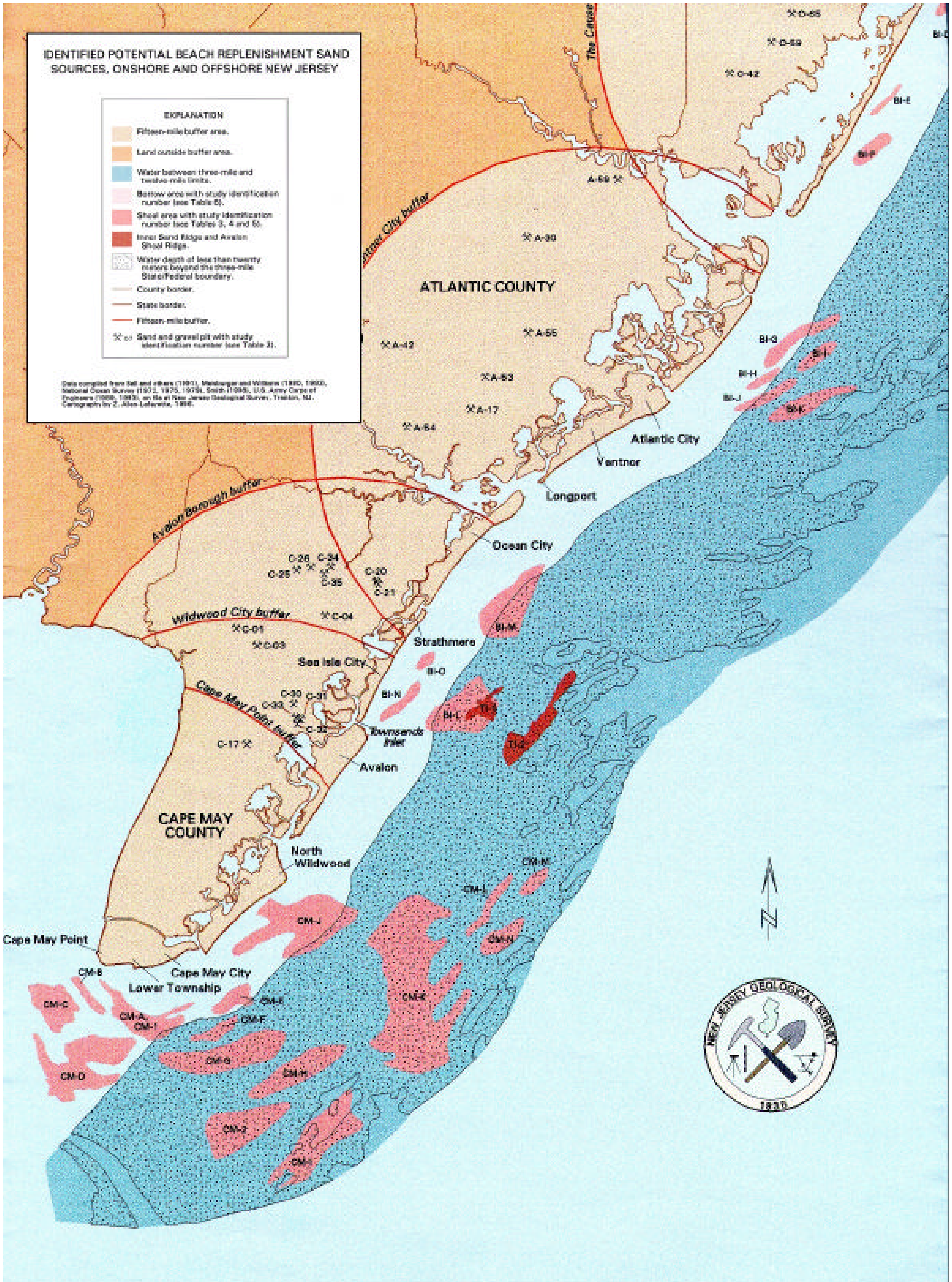


Figure 2-20b. Identified potential beach replenishment sand sources, onshore and offshore New Jersey (from Uptegrove *et al*. 1997).

Designated inshore borrow areas for the Beach Erosion Control Project for the northern coastal area (Sea Bright to Ocean Township) and Asbury Park to Mansaquan are also indicated on Figure 2-20a. These areas and nearshore sand shoals at Cape May have adequate quantities of sand to meet future replenishment needs for these areas. Therefore, NJGS has targeted the area between Point Pleasant and Avalon for additional investigation (Figure 2-21). Detailed analysis has been conducted on two shoals offshore of Townsends Inlet (TI-1 and TI-2 on Figure 2-20b).

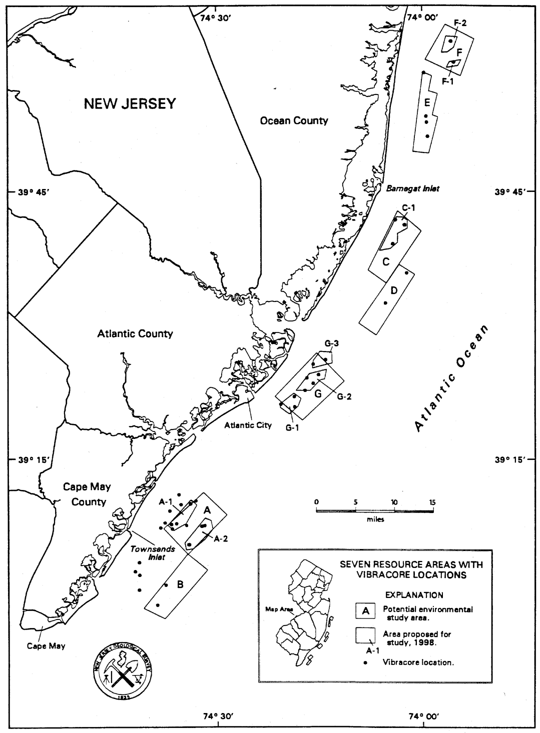


Figure 2-21. Targeted potential sand resource areas offshore New Jersey (from New Jersey Geological Survey).

Smith (1996) investigated shelf features in waters less than 25 meters (81 feet) deep within 20 km (12 miles) offshore the coastline between Great Egg Harbor Inlet and Hereford Inlet. Seismic and vibracore data were used by Smith (1996) to characterize sediments in this region. Surficial and subsurface sands are present as shelf sheet sands, linear sand ridges, and paleochannel fills and are characterized below.

1. Texture

Sand ridge sediments are characterized as a moderately sorted, gravelly, coarse sand with a mean grain size of 0.82 phi (Table 2-3). Buried fluvial channel deposits are characterized as poorly sorted gravelly coarse sand, having slightly more gravel and mud.

2. Resource Potential

Shore detached sand ridges and buried fluvial channels are viable sources of sand in Federal waters off New Jersey. Quantities of available sand have been estimated only for two sand ridges (Inner Ridge and Avalon Shoal). Buried fluvial channel deposits greater than three meters thick are indicated. Further detailed mapping is needed to assess the resource potential of these deposits and estimate sand quantitities. A river/baymouth shoal complex between Corsons Inlet and Townsends Inlet is another potential sand source warranting further investigation (Figure 2-22).

Table 2-3. Characteristics of Sand Ridges and Buried Channel Sediments off New Jersey

Environment	Sand Ridge	Buried Channel
Number of Analyses	60	14
Sorting (phi)	0.98	1.59
Maximum value	1.86	2.48
Minimum value	0.41	0.52
Description	moderate	poor
Mean (phi)	0.82	0.83
Maximum value	2.35	2.11
Minimum value	-1.02	-0.64
Corresponding sediment type	coarse sand	coarse sand
Skewness	-0.19	0.13
Maximum Value	0.45	0.60
Minimum Value	-0.63	-0.50
Descriptor	coarse	fine
% Gravel, Mean	9.96	12.36
% Gravel, Median	3.85	6.66
Maximum Value	44.80	41.10
Minimum Value	0.04	0.00
% Sand, Mean	89.32	81.55
% Sand, Median	95.96	86.10
Maximum Value	99.72	97.42
Minimum Value	54.61	56.57
% Mud, Mean	0.76	6.08
% Mud, Median	0.04	5.54
Maximum Value	5.35	14.77
Minimum Value	0.00	0.47

Source: Smith (1996)

3. Volume

The estimated sand volumes for potential borrow sites identified by Meisburger and Williams (1980, 1982) and shown in Figure 2-20 are presented in Table 2-4 and Table 2-5.

Shoal BI-L of Meisburger and Williams (1982) encompasses the Inner Ridge Sand Ridge of Smith (1996). Sand resource volumes of the Inner Ridge Sand Ridge and Avalon Shoal have been recalculated using analog and digital data sets (Table 2-6). The lower sand ridge boundary is defined as two meters above the underlying regional unconformity to exclude fine grained sediments at the base of ridges. Lateral boundaries are defined by the five-meter contour above the regional unconformity. Sand volumes were estimated as the total sediment thickness above the unconformity confined by the five-meter contour. The contour maps produced by the two data sets were distinct enough to produce different volume estimates. The vertical and horizontal resolution of digital data are more accurate.

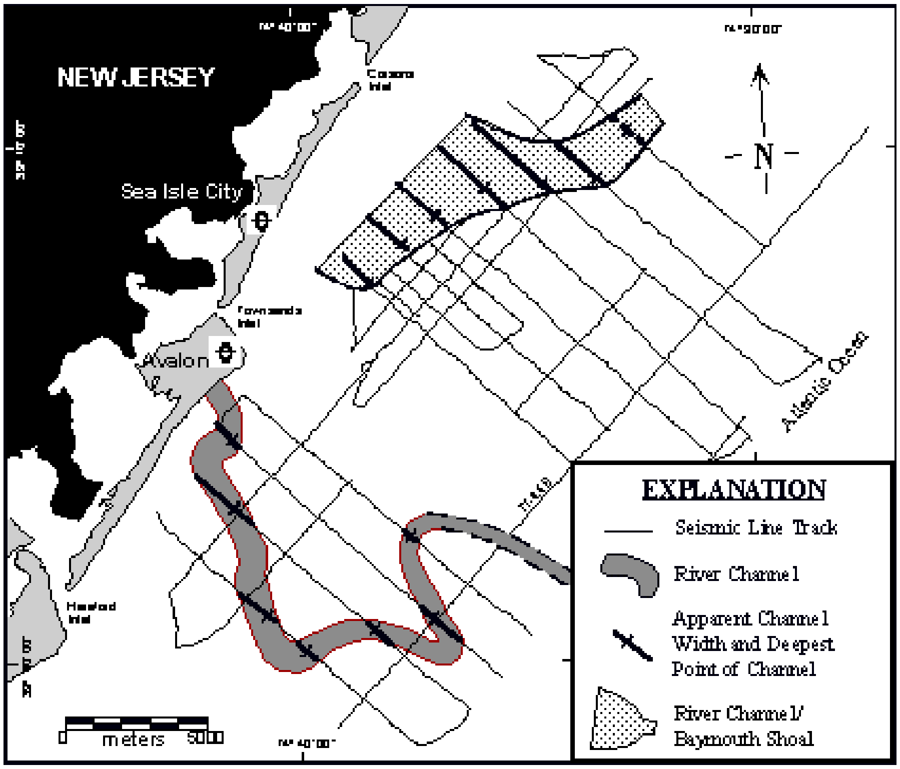


Figure 2-22. Deeply incised channels in seismic profile below the S_2 unconformity (from Smith 1996).

Table 2-4. Sand Shoals Offshore of Cape May, New Jersey

These shoals were originally identified in Meisburger and Williams (1980). Shoal IDs (Uptegrove *et al.* 1997) correspond to shoal labels on Figure 2-20b. Shoal CM-A on Figure 2-20b includes Area CM-1 (from Uptegrove *et al.* 1997).

Shoal ID	Water Depth (ft)	Area (x 10^6 yd^2)	Deposit thickness (ft)	Estimated volume (x 10^6 yd^3)
CM-A	6 to 30	10.914	5	18.182
CM-B	6 to 12	3.555	5 to 10	6.499
CM-C	12 to 38	14.617	5 to 20	41.079
CM-D	10 to 40	38.962	5 to 15	89.265
CM-E	23 to 33	6.765	5 to 10	14.644
CM-F	22 to 34	5.990	5 to 10	13.163
CM-G	18 to 42	29.417	5 to 20	84.328
CM-H	44 to 53	20.099	5 to 20	53.230
CM-I	40 to 60	33.778	5 to 20	120.860
CM-J	18 to 42	54.222	5 to 20	189.554
CM-K	20 to 60	125.580	5 to 30	617.477
CM-L	26 to 60	25.383	5 to 25	94.943
CM-M	44 to 65	3.901	5 to 20	10.794
CM-N	50 to 65	8.543	5 to 10	20.979
CM-1	6 to 30	*	*	Est. 14.5
CM-2	39 to 53	*	*	Est. 20.6

* CM-1 and CM-2 are not discernable topographic or seismic features.

Table 2-5. Sand Shoals Offshore of Central New Jersey

These shoals were originally identified in Meisburger and Williams (1982). Shoal IDs (Uptegrove *et al.* 1997) correspond to shoal labels on Figure 2-20a and b. Area BI-L encompasses the Inner Sand Ridge, one of two shoals located offshore of Townsends Inlet and characterized in Smith (1996) (from Uptegrove *et al.* 1997).

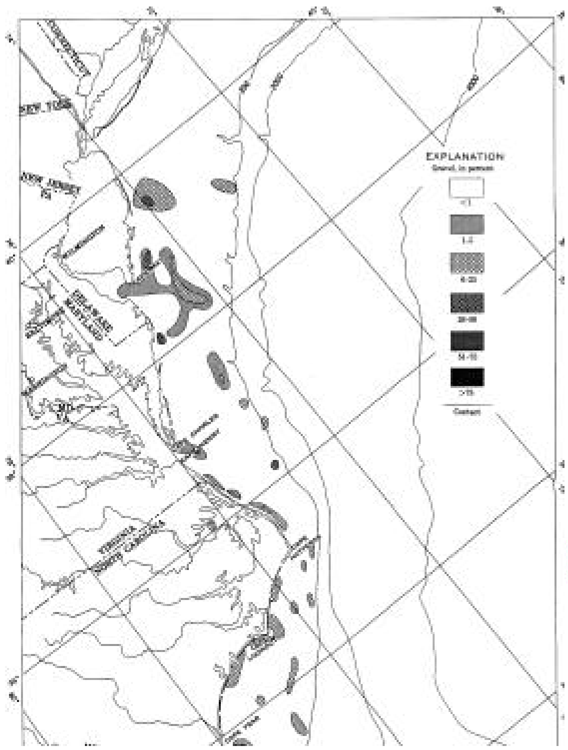
Shoal ID	**Water depth (m)**	**Area (x 10^6 m^2)**	**Average deposit thickness (m)**	**Estimated volume (x 10^6 m^3)**
BI-A	2 to 9	4.87	1.5	11.14
BI-B	9 to 13	2.76	1.2	5.90
BI-C	9 to 13	3.97	1.5	12.72
BI-D	9 to 13	5.96	1.8	25.18
BI-E	6 to 9	1.67	1.8	4.44
BI-F	7 to 11	4.30	1.5	8.38
BI-G	7 to 11	8.34	1.8	28.50
BI-H	9 to 11	1.46	2.1	4.54
BI-I	9 to 13	4.07	1.8	14.92
BI-J	9 to 15	6.03	1.5	14.70
BI-K	15 to 16	9.36	1.8	27.84
BI-L	9 to 15	2.41	2.4	5.86
BI-M	9 to 16	2.34	2.5	5.94
BI-N	9 to 11	0.49	2.7	1.32
BI-O	9 to 11	0.24	2.3	0.56

Table 2-6. Sand Resource Volumes of the Inner Sand Ridge and Avalon Shoal, New Jersey

Sand Resource Volumes	**Inner Sand Ridge (million cubic yards)**	**Avalon Shoal Sand Ridge (million cubic yards)**	**Total Sand Resource Volume (million cubic yards)**
analog data	63.3	48.8	112.1
digital data	50.616	74.247	124.863

Source: Uptegrove et al. (1997)

2.2.2.5 Delaware Continental S



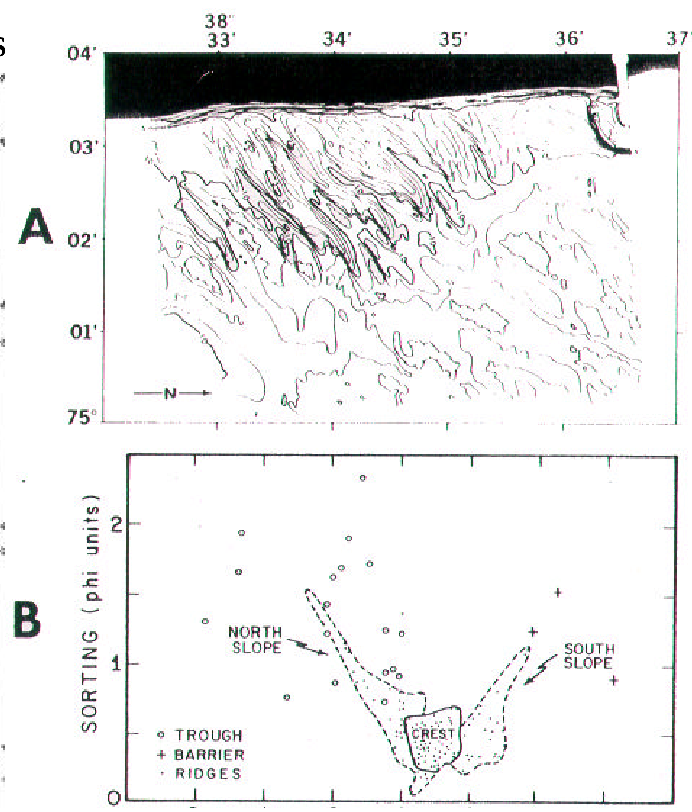


Figure 2-23. Percentage distribution of gravel in surface sediment off the Middle and Southern Atlantic States (from Milliman 1972).

Figure 2-24. Shoreface-connected ridge field off Bethany Beach, Delaware. (A) Bathymetry and (B) median diameter vs. inclusive graphic standard deviation for Bethany Beach Sediment types, from Moody (1964) (from Duane, *et al.* 1972).

Duane *et al.* (1972) describe the findings of Moody (1964) on the grain size gradient across the shore-attached ridge field opposite Bethany Beach (Figure 2-24). Pebbly, coarse sands cover the surface of ridge troughs. Moving in the seaward direction from north ridge slope to south ridge slope, toward the adjacent ridge crest, the coarse trough sands grade to medium sands and become better sorted at the crest. Sands continue to become finer, but become less well sorted, down the south slope to the next trough where sands are, again, coarse and pebbly.

b. Subsurface

The subsurface of the shelf off the coast of Delaware is described in Sheridan *et al.* (1974) (Figure 2-25). Geophysical and vibracore data identify an undulating pre-Holocene erosional surface overlain with sedimentary units of variable thicknesses. These units consist of lagoonal muds and clays; estuarine or shallow marine silts; nearshore shallow marine sands; and gravels. Sands may be shelly. The pre-Holocene surface and younger horizontal unconformities underlying some shoals are recognizable as seismic reflection surfaces. A basal peat with fringing marsh mud may lie immediately on the pre-Holocene surface.

The surficial sand sheet is often configured as ridges and swales. Thick sand units are associated with shoals. This is illustrated in diagramatic cross sections of the Delaware shelf extending eight nautical miles off Rehoboth Beach and four nautical miles off Bethany Beach (Figures 2-26 and 2-27).

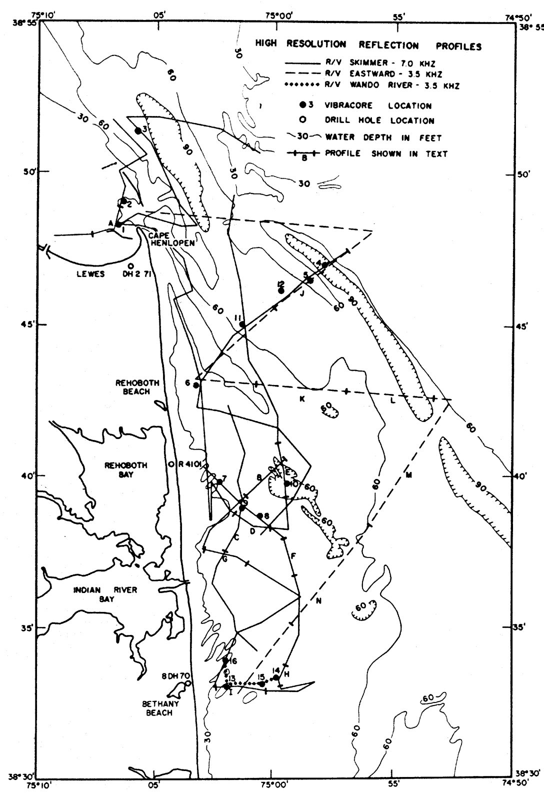


Figure 2-25. Location map of high resolution 3.5 and 7 kHz reflection profiles and vibracores off the coast of Delaware (from Sheridan *et al.* 1974).

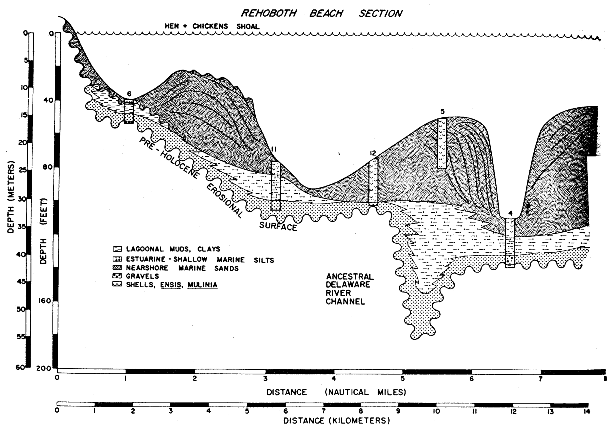


Figure 2-26. Geologic cross-section northeast of Rehobeth Beach, Delaware. Numbers represent vibracores which are located in Figure 2-25 (from Sheridan *et al.* 1974).

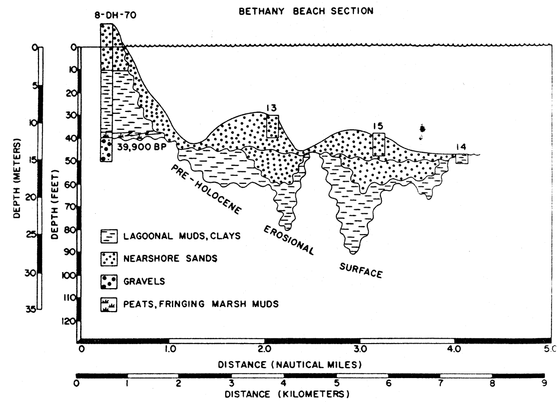
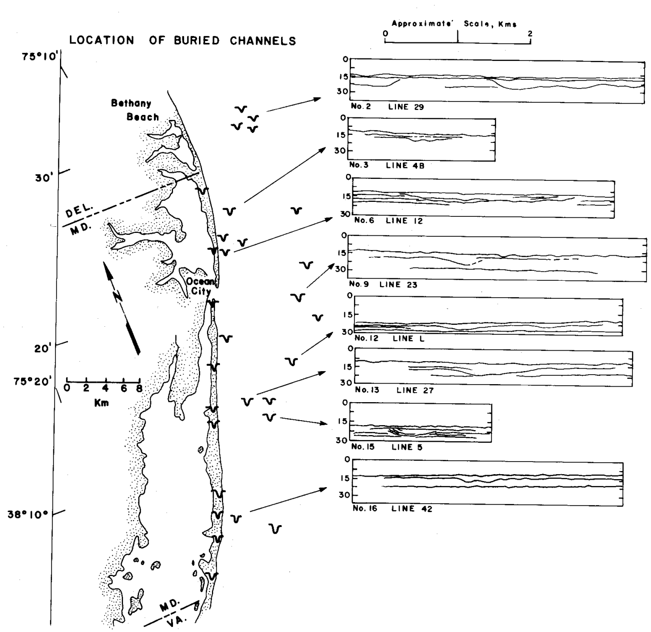


Figure 2-27. Geologic cross section east of Bethany Beach. Numbers 13-15 represent vibracores and 8-DH-70 designates deep-drill hole on land which are located in Figure 2-25 (from Sheridan *et al.* 1974).

Buried channels have been identified beneath the continental shelf off Bethany Beach (Field 1980) (Figure 2-28). The pre-Holocene surface is incised with valleys (Sheridan *et al.* 1974). The ancestral Delaware River channel is floored with a sand unit, but the other paleochannels described by Sheridan *et al.* (1974) are mud filled (Figures 2-26 and 2-27). These include the paleodrainages out of Rehoboth and Indian River Bays.



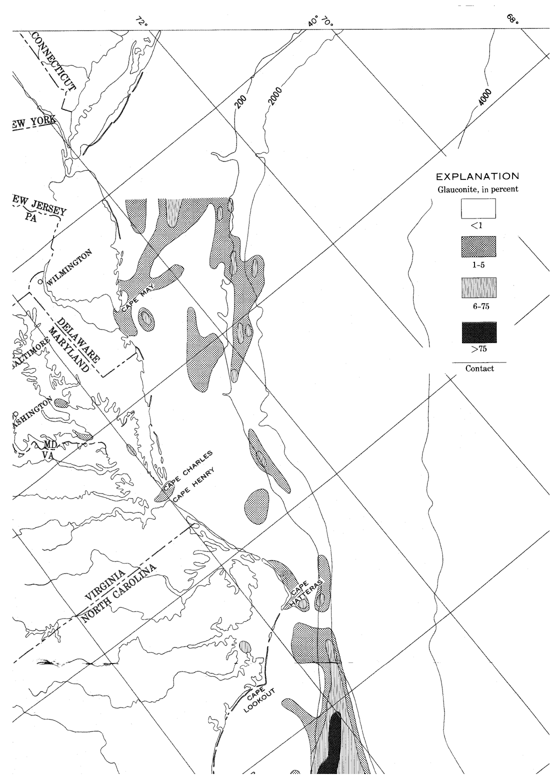


Figure 2-28. Locations and examples of interpreted acoustic profiles of buried channels on the inner shelf between Bethany Beach, DE and the MD-VA line (from Field 1980).

Figure 2-29. Percentage distribution of glauconite in surface sediment (insoluble 125μ to 250μ fraction) off Middle and Southern Atlantic States (from Milliman 1972).

2. Composition

a. Mineralogy

Terrigenous sands are predominantly quartz and feldspar and are low in carbonates and mica (Milliman 1972). There is a glauconite high on the shelf about 20 miles off the mouth of Delaware Bay (Figure 2-29).

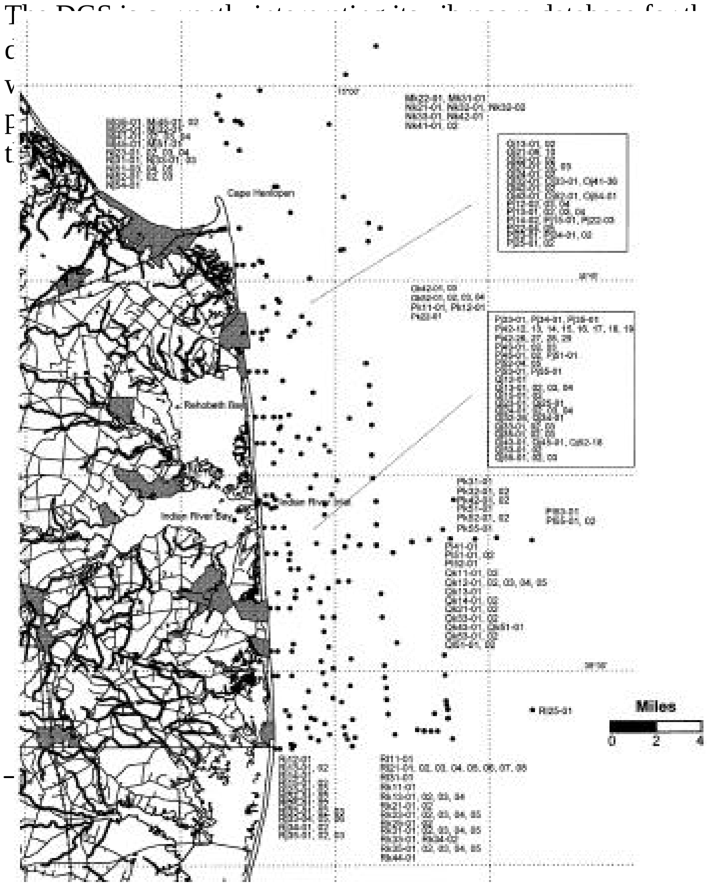
b. Trace Metals

The concentration of nine trace metals (barium, cadmium, chromium, copper, iron, lead, nickel, vanadium, zinc) in surficial sediments is provided in Appendix B. Concentrations generally correlate with the abundance of fine grained sediment and are low compared to average crustal rocks (Bothner 1979). It should be noted that the areas sampled in Bothner (1979) did not include known areas of waste disposal or other anthropogenic point sources of metals on the continental shelf.

The distribution of iron oxide on the continental shelf is presented in Appendix B. The occurrence and degree of iron staining of grains decreases with decreasing grain size (Milliman 1972). The distribution of the iron stained fine sand fraction of continental shelf sediments is shown in Figure 2-19.

B. Identified Offshore Sand Resources

1. Indian River Inlet and Fenwick Shoal



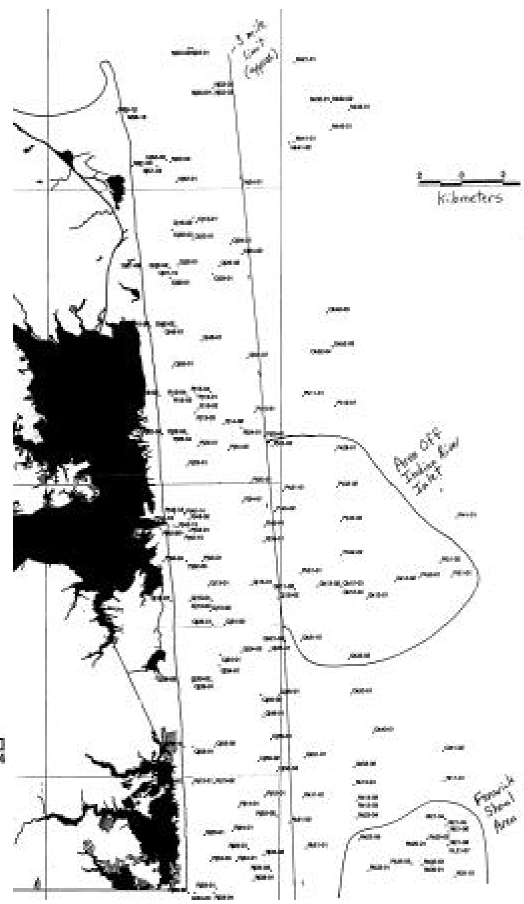


Figure 2-30. Overall vibracore database for the state of Delaware, including the Indian River Inlet site and the Fenwick Shoal Field off the southern state boundary of Delaware (from DGS).

Figure 2-31. Preliminary vibracore evaluation delimiting the suitable sand deposits of Indian River Inlet and the Fenwick Shoal Fields in Delaware. (from DGS).

The Indian River Inlet site is a relatively flat area. The sands here are related to ebb/flood tidal delta shoals associated with the inlet. Fenwick Shoal is located in a ridge and swale field near the Maryland border. The southern end of Fenwick Shoal crosses into Federal waters off Maryland.

a. Texture

DGS has analyzed native beach sand textures and recommends borrow sand textural criteria for beach nourishment (Ramsey 1999b). The optimum texture of sands to nourish the beaches of Delaware are a median grain size of 1.5 to 0.5 phi; 0.5 or less phi sorting; and negative skewness. The Indian River Inlet and Fenwick Shoal areas contain sands that meet the grain size criteria for beach nourishment along the Delaware coast.

b. Resource Potential

Core and seismic analysis are ongoing to target smaller areas within the above two areas that have the greatest potential to contain suitable sands. DGS has established good control of onshore coastal plain stratigraphy at the shoreline and is using vibracore and seismic data to extrapolate that record offshore to the Indian River Inlet and Fenwick Shoal potential resource areas to predict the location of suitable sand units.

c. Volume

The Indian River Inlet resource area extends over a 5 km X 6 km area. The upper 10 feet is estimated to have approximately 60 million cubic yards (46 million cubic meters; 62 million tons) of suitable and available sand (Ramsey 1999a). The Fenwick Shoal site in Delaware extends over a 5 km X 3 km area. The upper 10 feet is estimated to have approximately 44 million cubic yards (34.5 million cubic meters; 46 million tons) of suitable and available sand. A third area lies to the northwest of Fenwick Shoal and contains approximately 10-12 million cubic yards. The extent of the sand body in this area is poorly defined.

2.2.2.6 Maryland Continental Shelf

A. Regional Sediment Characteristics

1. Grain Size

Two studies that characterize the overall sediment properties of the Maryland continental shelf are Field (1980, inner shelf to 25m depth/40 km) and Kerhin (1989, inner shelf to 18m depth/25 km). These reports have been used to provide an overview of regional sediment characteristics.

a. Surface

Surface sediments are mostly terrigenous sand and silt with locally abundant clay (Field 1980). Gray-brown, fine to coarse, well-sorted quartz sands dominate.

The northern shelf off Ocean City is over 90 percent sand with the non-sand size fractions increasing south of Ocean City (Kerhin 1989) (Figure 2-32). The sand fraction coarsens in a southerly direction from generally fine to medium sand offshore Ocean City to medium and coarse sands towards the Maryland-Virginia border (Figure

2-33). Muddy sands (greater than 10 percent mud) are located close to shore in the shoreface and in the swales that separate linear sand ridges (Figure 2-34). An abundance of granule to pebble sized gravel is found in two areas (Figure 2-35). Gravel abundances as high as 50 percent are found at the most seaward of the two areas.

b. Subsurface

Toscano *et al.* (1989), Toscano (1992), and Toscano and York (1992) identify the stratigraphic units on the inner shelf off Maryland. A Tertiary unit is characterized with steep internal reflectors and extensive channeling nears its top which is truncated with the M1 erosional surface. Ten meters of concordant strata with parallel and subparallel bedding (Q1 and Q2) overlies the M1 surface. Q1 and Q2 are separated by another erosional surface associated with channeling, M2. The upper meter of the Q1 unit below M2 consists of shelly sands. Q2 is mostly a mud unit consisting of 5 to 7 meters of fossiliferous dark greenish gray silty mud with fine sand laminae. Locally, the lower Q2 is a discontinuous sandy unit that ranges from

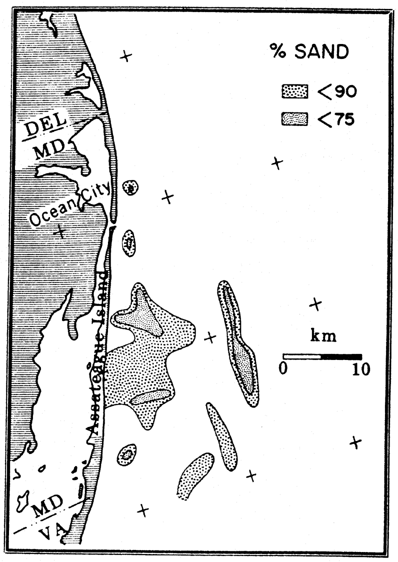


Figure 2-32. Distribution of percent sand in surficial sediment off MD. Unstippled area is > 90% sand (from Kerhin 1989).

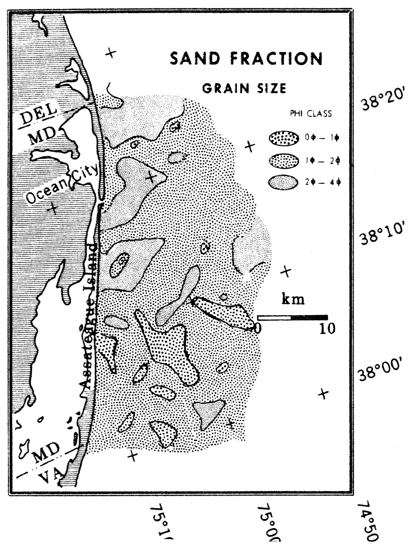


Figure 2-33. Distribution of mean grain size of sand fraction in surficial sediments off MD (from Kerhin 1989).

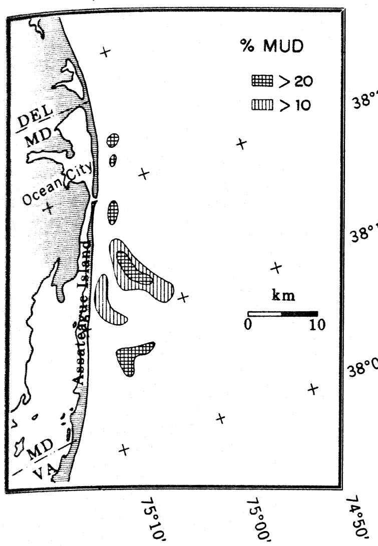


Figure 2-34. Distribution of percent mud in surficial sediments off MD (from Kerhin 1989).

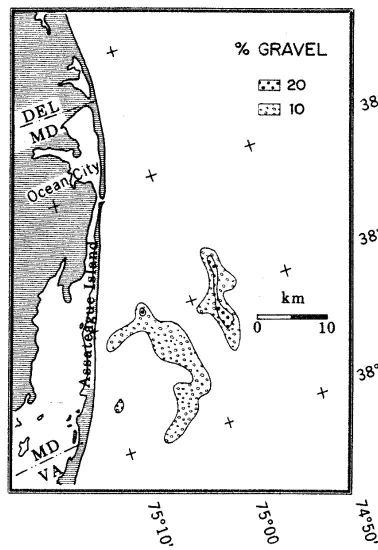


Figure 2-35. Distribution of percent gravel in surficial sediments off MD (from Kerhin 1989).

under one meter to thick to deposits on the scale of modern shelf shoals. Numerous paleochannels are incised in Q1 and Q2. Channel fill sands are represented by the Q3 unit. Q4 consists of estuarine channel fill sequences (esutarine channels, tidal streams, and tidal inlets) with a prevalence of muds and peats with channel fill sand. Modern shelf sands (Q5) cap the sequence. When Q5 is discontinuous, the Q2 unit outcrops on the seafloor.

Paleochannel fills that underlie linear sand ridges contain silty fine sands and sands with significant iron-oxide staining (Kerhin 1989). Nearshore tidal channel (or inlet) fills consist of fine sands, dark gray muds, and interbedded sand and mud. Paleochannels described by Toscano *et al.* (1989) on the Maryland shelf are indicated in Figure 2-36.

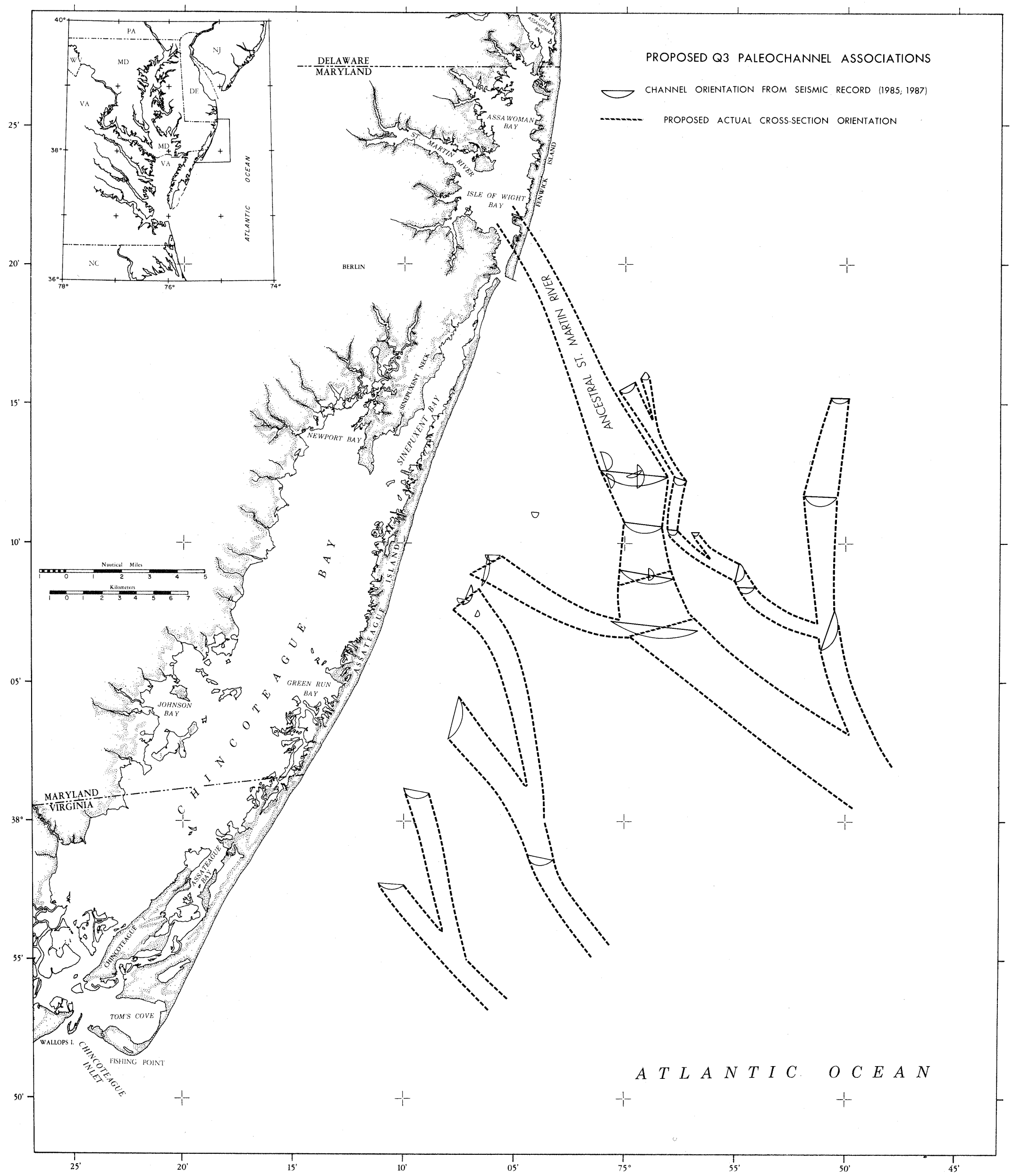


Figure 2-36 Paleochannels on the Maryland continental shelf (from Toscano *et al.* 1989)

2. Composition

a. Mineralogy

Terrigenous sands and silts are predominantly quartz and feldspar (Field 1980). Heavy minerals and mica are minor constituents, present only in trace amounts or a few percent. Nonterrigenous sediments include biogenic carbonates and authigenic glauconite. Fine-grained limonite (iron oxide) produces a red stain on some grains.

The carbonate fraction of sands on the Maryland continental shelf is less than five percent with the exception of a carbonate high (five to 25 percent) about 30 km (19 miles) off Ocean City (Milliman 1972). The carbonates of the inner shelf consist mostly of mollusks, echinoids, and foraminifers (Field 1980).

Heavy mineral layering has been found to occur in cores from linear shoals (Conkwright and Gast 1994a).

b. Trace Metals

The concentration of nine trace metals (barium, cadmium, chromium, copper, iron, lead, nickel, vanadium, zinc) in surficial sediments is provided in Appendix B. Concentrations generally correlate with the abundance of fine grained sediment and are low compared to average crustal rocks (Bothner 1979). It should be noted that the areas sampled in Bothner (1979) did not include known areas of waste disposal or other anthropogenic point sources of metals on the continental shelf.

The distribution of iron oxide on the continental shelf is presented in Appendix B. The occurrence and degree of iron staining of grains decreases with decreasing grain size (Milliman 1972). The distribution of the iron stained fine sand fraction of continental shelf sediments is shown in Figure 2-19.

B. Identified Offshore Sand Resources

Surficial and subsurface sands are found as sheet sands, linear sand ridges, and paleochannel fills (Field 1980; Swift and Field 1981; Kerhin 1989). Based on the work of Kerhin (1989) and Wells (1994), the Maryland Geological Survey (MGS) concluded that significant sand resources are mainly to be found in the linear, shore-detached sand ridges, or shoals.

In consideration of the economics and mechanics of sand dredging and sand emplacement on beaches, MGS confined its detailed assessment of potential offshore sources of sand for beach nourishment to waters less than 15 meters (50 feet) deep within 24 km (15 miles) of the shoreline. Within this area, MGS has delimited three shoal fields as potential offshore sand resources for beach nourishment (Figure 2-37). The sand shoals beyond the state three-mile limit are detached ridges, that is, they are defined by closed contours as opposed to being attached to the shoreface.

Seismic and vibracore data were used to characterize shoal field sediments (Conkwright and Gast 1994a, 1994b, 1995; Conkwright and Williams 1996). These reports are summarized below.

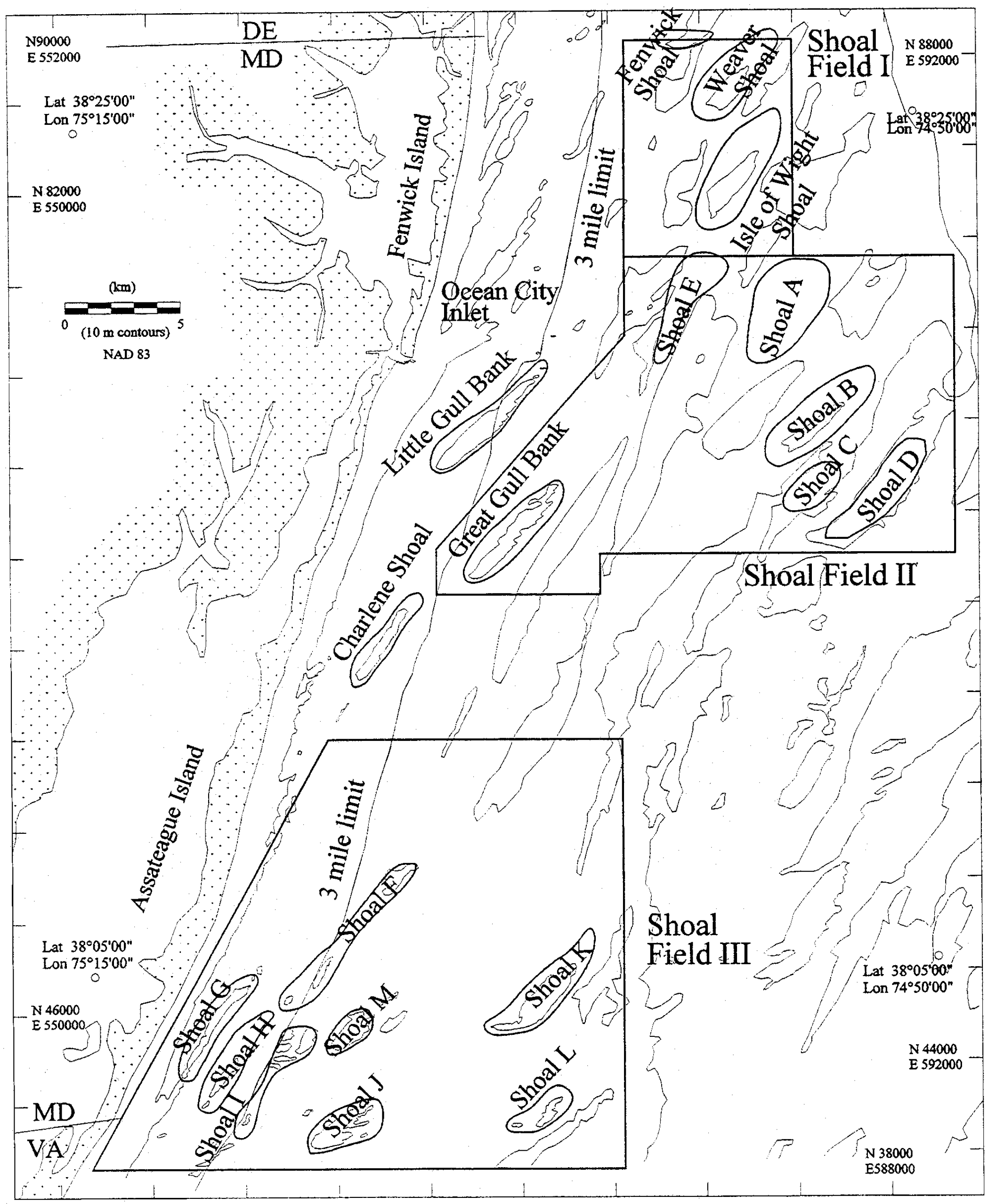


Figure 2-37. Three shoal fields off MD delimited by Maryland Geological Survey (from Conkwright and Williams 1996).

1. Shoal Field I

Shoal Field I is located about eight km (five miles) east of Fenwick Island, south of the Maryland-Delaware border, and north of Ocean City Inlet (Figure 2-37). Its landward edge is beyond the Federal three-mile limit and its seaward edge extends to about 14 km (nine miles) offshore. It includes Weaver Shoal, Isle of Wight Shoal and the extreme southwestern crest of Fenwick Shoal. They are entirely within Federal waters.

A relatively flat ravinement surface (erosional and depositional surface developed by the erosion and redistribution of shoreface sediments during the most recent Holocene rise in sea level) underlies the shoal field. This surface is evident as a basal reflector on seismic records. Shoal edge boundaries are marked by the thinning of shoal sediments to one meter or less or abrupt changes in lithology to fine material. Changes in lithology occur where shoal faces truncate ravinement surfaces.

a. Texture

Sediment grain size was examined at Weaver Shoal and Isle of Wight Shoal by Conkwright and Gast (1994a). Overall, Weaver Shoal is coarser. Mean grain sizes of Weaver Shoal samples were never finer than 1.84 phi (medium sand). While bulk samples at Isle of Wight Shoal were coarser than 1.84 phi near the crest, sediments become finer toward the flanks. The sorting of most of the Weaver Shoal sediments was less than 1.22 phi and ranged from poorly to very well sorted sands while Isle of Wight sands had sortings less than 1.1 phi and were moderately to very well sorted.

b. Resource Potential

Grain size and sorting properties of potential borrow material and native beach sand need to be compared in order to evaluate the acceptability of borrow sand for beach nourishment. Applying USACE methodologies for determining the suitability of borrow material for beach nourishment (see USACE, 1984), Weaver Shoal and Isle of Wight Shoal have been rated as potential sand sources for Fenwick Island (Ocean City) beach replenishment (Figure 2-38). Sand suitable for beach fill should have a mean grain size coarser than 1.84 phi (medium sand) and a sorting value less than 1.22 phi (moderately sorted).

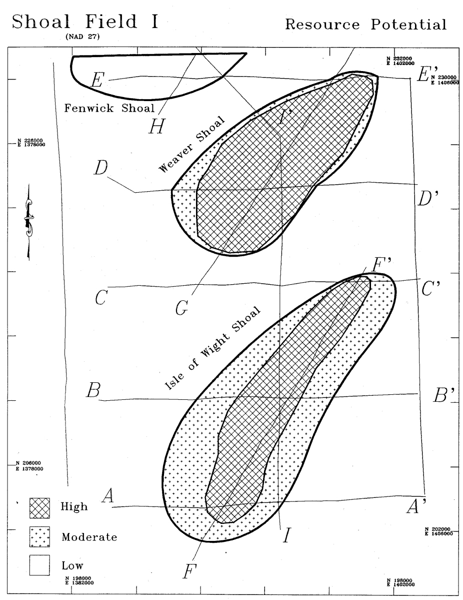


Figure 2-38. Resource potential of shoals within Shoal Field I. Seismic lines are indicated (from Conkwright and Gast 1994a).

The mapping of relative resource potential within Shoal Field I in Figure 2-38 is based on the following criteria. Areas with high resource potential are located in waters less than 15 meters (50 feet) deep. Sands of high potential are deposits that are greater than one meter thick, have a mean grain size coarser than 1.84 phi, and a sorting value less than 1.22 phi. Areas with moderate resource potential are located in waters nearly 15 meters (50 feet) deep or shallower. Sands of moderate potential are also greater than one meter thick but have marginal grain size similarities to the grain size criteria for sands suitable beach fill. Regions with fine sediment and/or deeper than 15 meters (50 feet) are rated as areas with low resource potential.

Following the aforementioned resource potential criteria, most of Weaver Shoal and the central portion of Isle of Wight Shoal are rated high. The flanks of Isle of Wight Shoal are rated moderate. Fenwick Shoal had been rated low, but new data (Spring 1999) indicate Fenwick Shoal can be classified as a high potential resource. Inter-shoal areas have low sand resource potential. Sediments there are fine and depths are greater than 15 meters (50 feet).

c. Volume

Total sediment volumes were estimated based on the entire shoal body (surface to basal reflector). The total shoal volume is 175.2 million cubic meters (229.1 million cubic yards). The total volume of moderate potential deposits is estimated to be 57.4 million cubic meters (75.1 million cubic yards). Total volume of deposits with high potential is estimated to be 117.7 million cubic meters (154 million cubic yards) (Table 2-7).

Table 2-7. Sediment Volumes of Maryland Shoal Fields

Shoal	Region	Volume (cubic million yards)
Weaver and Isle of Wight (Shoal Field I) (*Conkwright and Gast 1994a*)	total	229.1
	total high potential	154
	total moderate potential	75.1
Great Gull Bank, Shoals A,B,C,D,E (Shoal Field II) (*Conkwright and Gast 1994b*)	total	502
	total high potential	178
	total moderate potential	57
Great Gull Bank, Little Gull Bank, Shoals,B,C,D (Shoal Field II) (*Conkwright and Williams 1996*)	total high potential	95.7
	total moderate potential	31.7
Shoals F,G,H,I,J,K,L,M (Shoal Field III) (*Conkwright and Gast 1995*)	total	478.9
	total high potential	72.9
	total moderate potential	282.6

2. Shoal Field II

Shoal Field II is located south of Shoal Field I about six km (four miles) east of Ocean City Inlet (Figure 2-37). Its seaward edge extends to about 19 km (12 miles) offshore. It includes six shoals: Great Gull Bank, A, B, C, D, and E. They are entirely within Federal waters. The 1996 report expands its investigation of Shoal Field II to include Little Gull Bank due to its proximity to Assateague Island. Little Gull Bank is located within both State and Federal waters.

A ravinement surface underlies the shoal field and is evident as a basal reflector on seismic records. In the central portion of the shoal field this surface is relatively flat. It is irregular elsewhere. Shoal edge boundaries are marked by the thinning of shoal sediments to one meter or less or abrupt changes in lithology to fine material. Changes in lithology occur where shoal faces truncate ravinement surfaces. Inter-shoal areas contain buried channels.

a. Texture

Core description summaries from Shoal Field II are provided in Conkwright and Williams (1996). Grain size data indicate that Shoal B sands are coarsest along the crest, particularly in the south-west. Most cores contain sands that are 1.84 phi or coarser. The crest of Shoal C contains sands 1.84 phi or coarser with slightly finer sands (1.95 phi) found at depths of 14.4 to 15.6 meters. Sands on the northeast and flanks are too fine for beach fill (*i.e.*, finer than 1.84 phi). Coarse and well sorted sands are found along the crest of Shoal D to at least a depth of 13 meters. On the northwest edge only 0.5 meters of medium sand was found to overlie fine sand and mud. At Great Gull Bank, sands coarser than 1.84 phi are found along the southwestern crest to at least a 14 meters depth. Coarse to medium, moderately well sorted sands exist along the northwest flanks to a depth of 16 meters. Sands finer than 1.9 phi are found to a depth of 13.6 meters on the northeastern edge. At Little Gull Bank, coarse or medium well sorted sands are found to depths of 12 meters from the northeast to southwest ends of the shoal.

b. Resource Potential

Grain size and sorting properties of potential borrow material and native beach sand need to be compared in order to assess the acceptability of borrow sand for beach nourishment. Applying USACE methodologies for determining the suitability of borrow material for beach nourishment, Little Gull Island, Great Gull Bank and Shoals A, B, C, D, and E have been rated as potential sand sources for beach replenishment for Ocean City and northern Assateague Island. Sand most suitable for beach fill is predicted to have a mean grain size coarser than 1.84 phi (medium sand) and a sorting value less than 1.22 phi (moderately sorted).

The 1994 study (Conkwright and Gast 1994b) assessed resource potential using the following criteria. High resource potential sands are at depths less than 15 meters (50 feet) in deposits greater that one meter thick with a mean grain size coarser than 1.84 phi and a sorting value less than 1.22 phi. Shoal sands at depths near 15 meters (50 feet) or shallower in deposits greater than one meter thick with mixed or marginal grain size similar to suitable beach fill grain size criteria are classified as moderate resource potential areas. Shoals with fine sediment and/or deeper than 15 meters (50 feet) are rated as having low resource potential. Accordingly, in the 1994 report, parts of Shoals B, C, and D have a moderate resource potential and parts of each have a high resource potential. Portions of Shoal A, Shoal E, and Great Gull Bank have moderate and low resource potentials. Inter-shoal areas have low sand resource potential. Sediments there are fine and depths are greater than 15 meters (50 feet).

A modified resource potential map using different criteria is presented in the 1996 report (Conkwright and Williams 1996). High resource potential sands are at depths less than 15 meters (50 feet) with a mean grain size coarser than 1.84 phi and a sorting value less than 1.22 phi. Areas with less well sorted finer sands (mean grain size between 1.84 and 2.0 phi and sorting greater than 1.22 phi) or areas at depths of 15 meters (50 feet) or deeper are classified as moderate resource potential areas. Areas of low sand resource potential are those with sediments finer than 2 phi (fine sand and finer). Accordingly, Shoals B, D, Great Gull Bank,

and Little Gull Bank each have areas of high and low sand resource potential. Great Gull Bank and Little Gull Bank also have areas of moderate potential. Shoal C is assessed as moderate to low resource potential.

c. Volume

Two sets of volume calculations were made for Shoal Field II. The 1994 study was based on seismic and archival vibracore data. The lower boundary for volume calculations was the basal reflector (ravinement surface). Thus, total sediment volumes were estimated for Great Gull Bank and Shoals A, B, C, D, and E based on the entire shoal body (surface to basal reflector). In contrast, the lower boundary used for the volume calculations of the 1996 study are based on measured parameters, i.e., grain size parameters of recently taken vibracores that did not reach the basal reflector. Thus, the 1996 report presents volume calculations of minimum quantities (volumes calculated only to depth of vibracore penetration or material unsuitable as beach fill) for Great Gull Bank and Shoals B, C, and D.

The 1994 report indicated that the total sand volume for Great Gull Bank and Shoals A, B, C, D, and E is 383.8 million cubic meters (502 million cubic yards), the total volume of moderate potential regions is 43.6 million cubic meters (57 million cubic yards), and the total volume of high potential regions is 136.1 million cubic meters (178 million cubic yards). The 1996 report indicates that the total minimum volume of high potential sand resources in Great Gull Bank and Shoals B, C, and D is 73.2 million cubic meters (95.7 million cubic yards) and the total minimum volume of moderate potential sand resources is 24.2 million cubic meters (31.7 million cubic yards) (Table 2-7).

3. Shoal Field III

Shoal Field III is located south of Shoal Field II about 18 km (ten nautical miles) south of Ocean City Inlet (Figure 2-37). Its landward edge is within State waters between one and two kilometers (3/4 nautical mile) off Assateague Island and its seaward edge extends to about 22 km (14 miles) offshore. It includes eight shoals: F, G, H, I, J, K, L, M.

Shoals G and H lie entirely within State waters. Shoals F and I are located in both State and Federal waters. Shoals J, K, L, and M lie entirely within Federal waters.

A ravinement surface underlies the shoal field and is evident as a basal reflector on seismic records. West of Shoal M, this surface is relatively flat. It is irregular to the east of Shoal M. Shoal edge boundaries are marked by the thinning of shoal sediments to one meter or less or abrupt changes in lithology to fine material. Changes in lithology occur where shoal faces truncate ravinement surfaces. Inter-shoal areas contain buried channels.

a. Texture

Sediment grain size was examined at Shoal Field III by Conkwright and Gast (1995). The bulk of Shoal F contains fine to medium sand that may mix with muds toward the base. Shoal G consists of fine to medium sands overlying finer sediments. At Shoal H, medium sands are found near the crest with fine sands overlyling fime to medium sands towards the flanks. Sediment textures with depth are variable in the central section, changing from medium sand to fine sand to, perhaps, muddy sand. The northeast section of Shoal I is covered with at least 10 feet of medium sand and the central section contain fine sediments, similar to Shoal H. At Shoal J, one foot of coarse to medium sand is found on its southeast flank. The western flank contains 16 feet of fine sand. The central portion has 5 to 8 feet of medium to coarse sands overlying fine sands. Medium to coarse sands also are found in the central and northeastern regions of Shoal K. Finer sands are found in the southwest and along flanks. The central section likely contains ten or more feet of medium to coarse sand overlying medium to fine sands. The central section of Shoal L has fine sand. A small central region of Shoal M contains medium sand along its crest to shallow depths.

b. Resource Potential

Grain size and sorting properties of potential borrow material and native beach sand need to be compared in order to assess the acceptability of borrow sand for beach nourishment. Applying USACE methodologies for determining the suitability of borrow material for beach nourishment, Shoals F, G, H, I, J, K, L, and M were rated as potential sand sources for Assateague Island beach replenishment using data from Ocean City beach sands due to the unavailability of grain size data for Assateague Island beach sands at the time of the MGS resource potential assessment. Sand most suitable for beach fill must have a mean grain size coarser than 1.84 phi (medium sand) and a sorting value less than 1.22 phi (moderately sorted).

High resource potential sands are at depths less than 15 meters (50 feet) in deposits greater than one meter thick with a mean grain size coarser than 1.84 phi and a sorting value less than 1.22 phi. Shoal sands at depths near 15 meters (50 feet) or shallower in deposits greater than one meter thick with mixed or marginal grain size similarities to suitable beach fill grain size criteria are classified as moderate resource potential areas. Deposits with fine sediment and/or deeper than 15 meters (50 feet) are rated as having low resource potential.

Accordingly, parts of Shoal F and Shoal K have a moderate resource potential and parts of each have a high potential. Portions of Shoal H and Shoal I and all of Shoal J, Shoal L, and Shoal M have moderate resource potential. All of Shoal G is rated as low resource potential. Inter-shoal areas have low sand resource potential. Sediments there are fine and depths are greater than 15 meters (50 feet).

c. Volume

Total sediment volumes were estimated based on the entire shoal body (surface to basal reflector). The total shoal volume is 336.2 million cubic meters (478.9 million cubic yards). Total volume of moderate potential regions is estimated to be 216.1 million cubic meters (282.6 million cubic yards). The total volume of high potential regions is estimated to be 55.7 million cubic meters (72.9 million cubic yards) (Table 2-7).

2.2.2.7 Virginia Continental Shelf

A. Regional Sediment Characteristics

1. Grain Size

a. Surface

General mapping of continental shelf sediments indicates that surficial sediments off the Virginia coast are detrital sands with varying mixtures of silt and clay (Milliman 1972; Hollister 1973; MMS 1994). Sediments with less than 75 percent sand (very fine and fine grained sand) mixed with silt are found extending beyond the Federal limit as a plume of sediments bulging seaward off the entrance of Chesapeake Bay and tapering north and south of the bay entrance towards the Maryland and North Carolina borders (Map 2, MMS 1994). Seaward of this plume, sands coarsen to generally more than 75% medium to coarse sand. Southward towards the North Carolina border, the finer sand sheet grades seaward to the coarser sand sheet inside the Federal limit. Gravelly sands pockets have been mapped near the shelf edge opposite Cape Charles and Cape Henry (Map 2, MMS 1994) and nearer the shore between Cape Henry and False Cape (Figure 2-39).

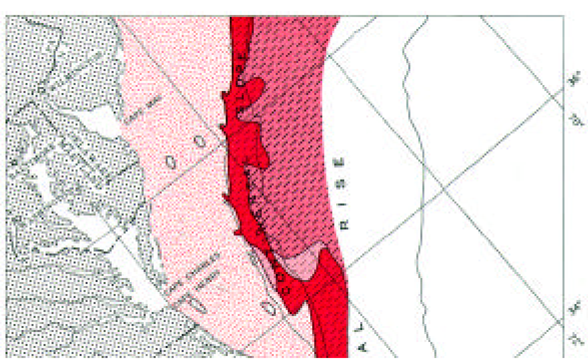


Figure 2-39. Distribution of general sediment textures from New Jersey to North Carolina (from Hollister 1973).

More detailed studies of grain size parameters have been conducted on the shelf opposite the bay entrance and northward off the lower Delmarva Peninsula (Wright *et al.* 1987) and off southeast Virginia south of Chesapeake Bay, from Cape Henry to False Cape (Duane *et al.* 1972; Swift *et al.* 1973, 1977; Hobbs 1997).

Based on bed roughness, the inner shelf bottom off Virginia has been classified as Type Ia at the shoreface and as Type Ib in ridge fields seaward of the shoreface (Wright *et al.* 1987; Hobbs 1997) (Figure 2-40). Both areas have little biogenic roughness, particularly Type Ia due to the lack of benthic colonization in the surf zone. Both have current and wave induced bedforms which lead to bed roughness. The influence of currents on bottom roughness and bedforms is greater in Type Ib. Bottom roughness is also affected by drag marks produced by fishing equipment.

The surficial sediments of southeast Virginia are mostly sand and granule sized in excess of 90 to 95 percent (Figures 2-41, 2-42, and 2-43) (Hobbs 1997). Isolated areas with reduced coarse sediment content occur. The areal distribution of sand size classes for part of the southeast shelf is presented in Figures 2-44, 2-45, and 2-46 (Swift *et al.* 1977). The pattern displayed is a consequence of both the processes that formed the large scale features (shelf valley and shoal retreat massif) and the smaller scale ridge and swale topography. The general large scale grain size trend is a southerly fining from mostly medium to coarse grained sands on the shoal massif north of the Virginia Beach Valley to fine to very fine sands.

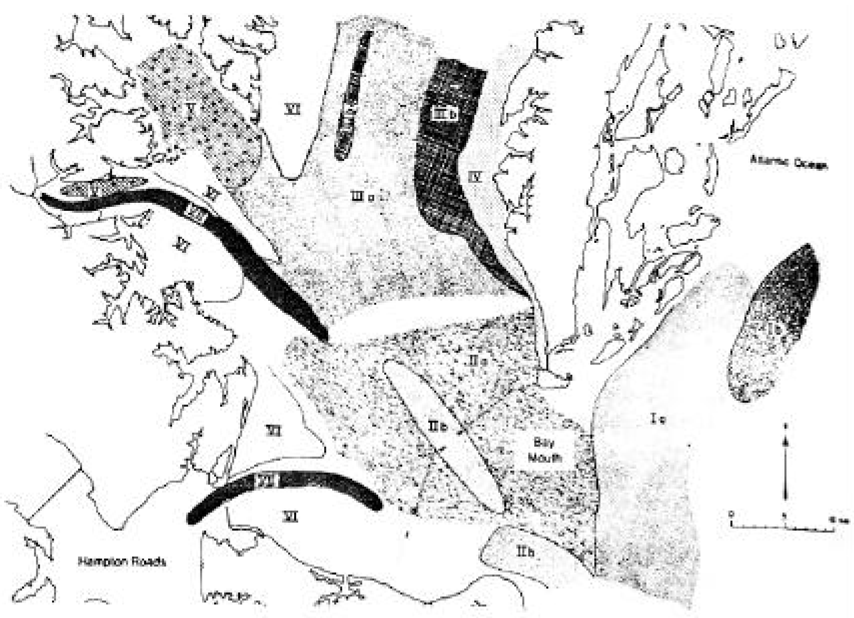


Figure 2-40. Spatial distribution of bottom types in the lower Chesapeake Bay and its adjoining estuaries and inner shelf (from Wright *et al.* 1987).

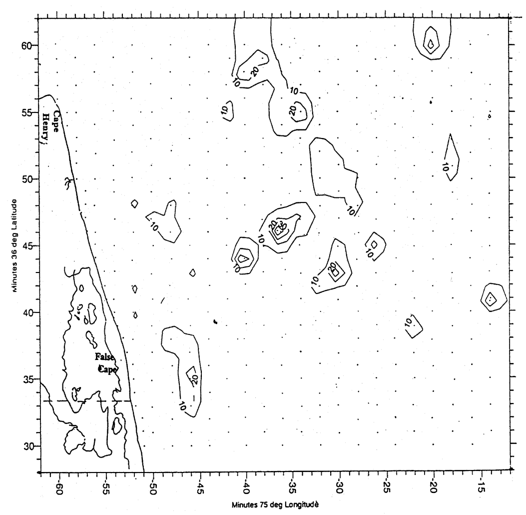


Figure 2-41. Contour plot of the weight percent granule in surficial sediments off VA from Cape Henry to False Cape. Contour interval is 10 percent (from Hobbs 1997).

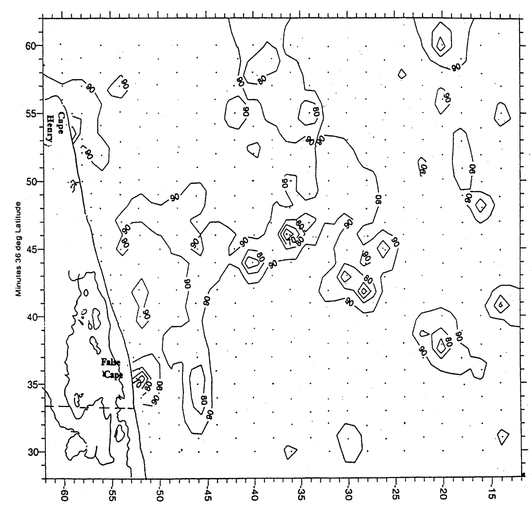


Figure 2-42. Contour plot of the weight percent sand in surficial sediments off VA from Cape Henry to False Cape. Contour interval is 10 percent (from Hobbs 1997).

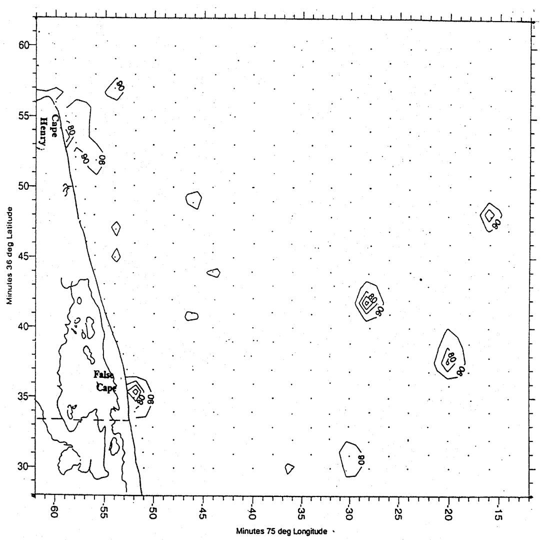


Figure 2-43. Contour plot of the weight percent granule plus sand in surficial sediments off VA from Cape Henry to False Cape. Contour interval is 10 percent (from Hobbs 1997).

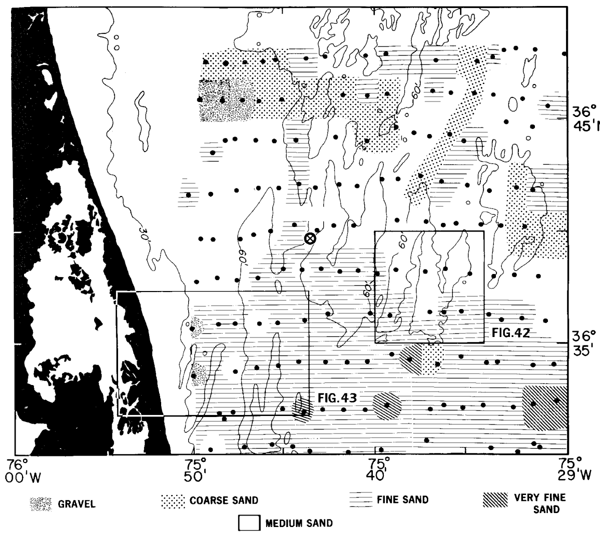


Figure 2-44. Distribution of median diameter of sand fraction for part of the southeast VA shelf. Boxes indicate locations of Figures 2-45 and 2-46 (from Swift *et al.* 1977).

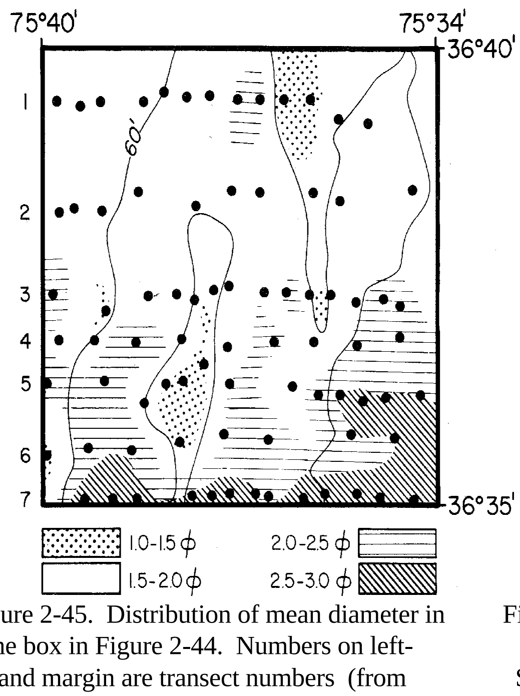


Figure 2-45. Distribution of mean diameter in the box in Figure 2-44. Numbers on left-hand margin are transect numbers (from Swift *et al.* 1977).

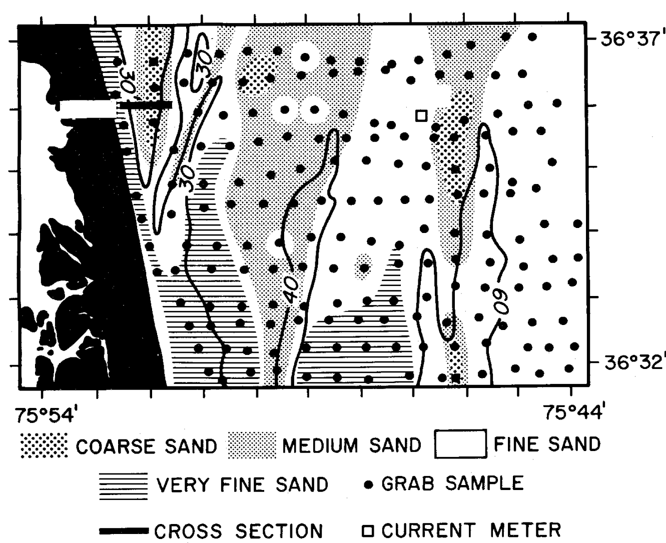


Figure 2-46. Distribution of median diameter of the sand fraction across the box in Figure 2-44. (from Swift *et al.* 1977).

Ridge fields exhibit grain size gradients (Duane *et al.* 1972; Swift *et al.* 1973, 1977). Shoal crests of the Virginia Beach Ridge System and the False Cape Ridge System (Figure 2-47) are predominantly well sorted medium to fine grained quartz sand while flank sands are fine to very fine grained. Intershoal troughs are floored with a discontinuous layer of pebbly medium to coarse sand a few centimeters thick that overlie compact greenish gray muddy sand and brown mud. The underlying material may be exposed and clay balls from the underlying mud are found in the pebbly sand layer. Landward flanks are coarser than seaward flanks. The fine and very fine sand of shoal flanks extend over coarser trough sands. Grain size sorting analysis shows that, at the False Cape Ridge field, crest sands are better sorted than trough sands and both crest and trough sands are better sorted with increasing grain size while flank sands are better sorted with decreasing grain size.

Figure 2-47. Bathymetry of the Virginia Beach shelf valley indicating location of the Virginia Beach Ridge System and the False Cape Ridge System. Contours are in feet (from Swift *et al.* 1977).

b. Subsurface

The standard stratigraphic section of the Virginia shelf was established by Shideler *et al.* (1972). It consists of four units, A (oldest) through D (youngest), each separated by regional unconformities seen as major reflectors on seismic records. Unit A correlates with the Yorktown Formation, a shelly, marine sequence. The overlying Unit B correlates with the Great Bridge Formation and Sandbridge Formation sequence of fluvial and nearshore deposits. Unit C consists of estuarine and lagoonal silts and clays. Unit D is the modern surficial sediment unit. Units B and C may be exposed. Subsurface data compiled in subsequent studies have been placed within this stratigraphic context, with some modification.

The vertical sequence underlying the shelf off Sandbridge reflects the complexity of the aforementioned stratigraphic framework. Figure 2-48A and B shows a cross section of the shelf along a transect that extends 7.4 km (four nautical miles) offshore. A sand shoal in federal waters, Sandbridge Shoal, is shown. The surface units range from silty clay to silty fine sand to medium coarse sand. Units encountered at depth beneath an overburden unit include medium coarse sand, medium sand, and silty clay.

Numerous named and unnamed paleochannel systems have been identified on the Virginia shelf (Kimball *et al.* 1991; Chen *et al.* 1995; Oertel and Foyle 1995) (Figures 2-49, 2-50, and 2-51). Hobbs (1997) discerns three types of paleochannel fill deposits on the Virginia continental shelf. Small, near surface, shore normal tidal inlet channels; small, relatively wide and shallow shore-parallel back-barrier channels; and riverine channels. Paleochannel fills are heterogenous in grain size.

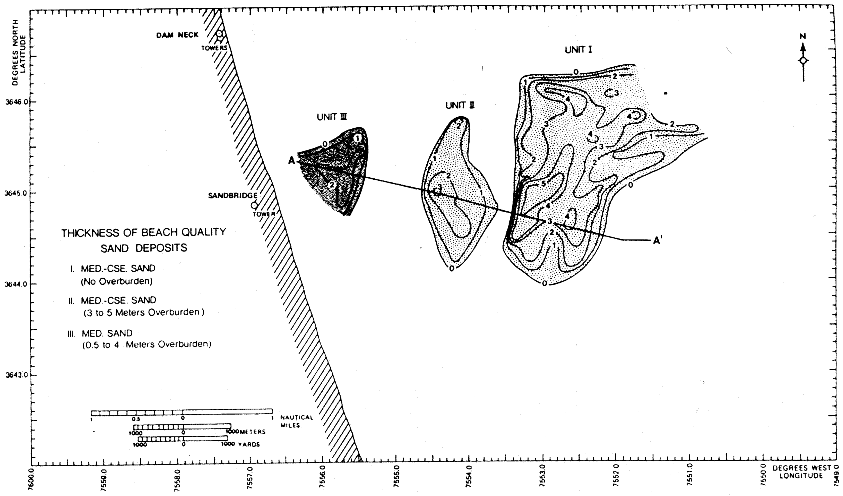


Figure 2-48A. Distribution and inferred thickness of medium to coarse sand deposits near Sandbridge Beach, VA. Contours indicate unit thicknesses in meters. Contour interval is one meter. Cross section of transect A-A' is shown in Figure 2-48B (from Kimball *et al.* 1991).

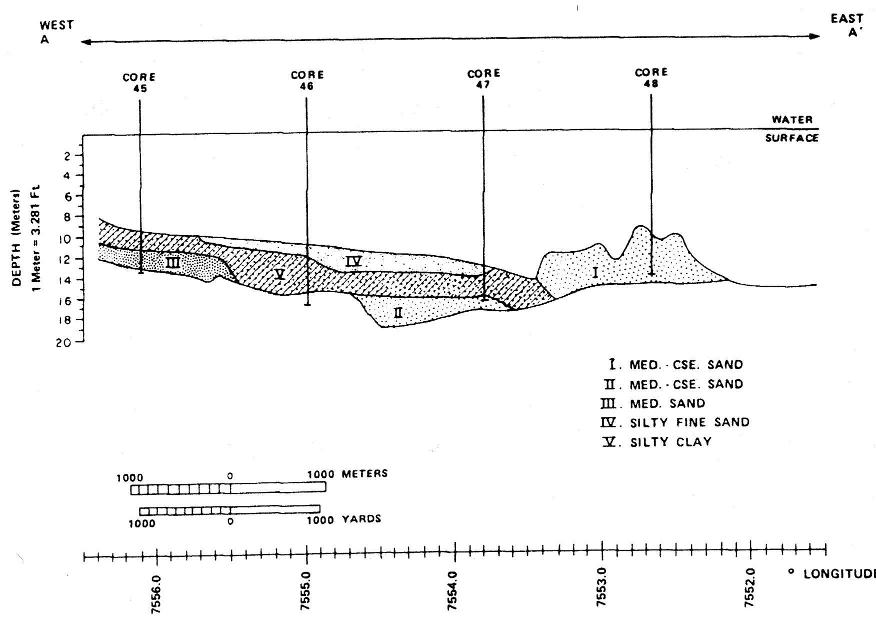


Figure 2-48B. Cross section along transect A-A' in Figure 2-48A showing vertical and lateral distributions of an isolated shoal and attendant sand bodies near Sandbridge Beach, VA (from Kimball *et al.* 1991).

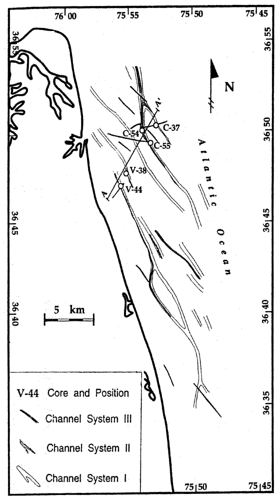


Figure 2-49. Three paleochannel systems south of Chesapeake Bay (from Chen *et al.*, 1995)

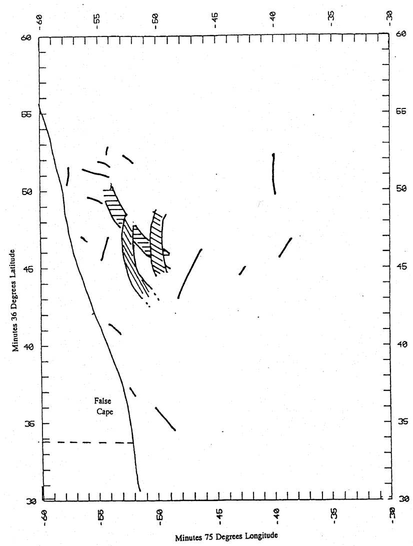


Figure 2-50. Filled paleochannels of portion of the continental shelf of southeastern Virginia from Cape Henry to the VA/NC border (from Hobbs 1997).

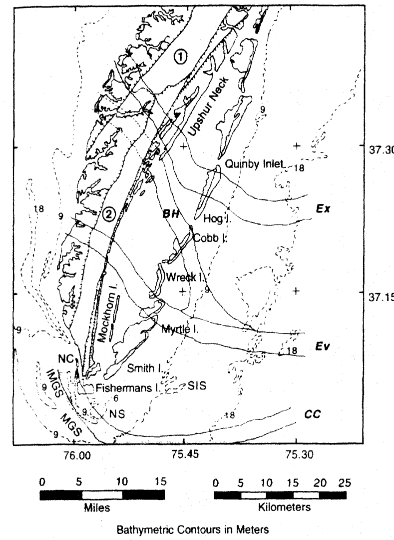


Figure 2-51. Locations of Exmore (Ex), Belle Haven (BH), Eastville (Ev), and Cape Charles (CC) paleochannel tracts (from Oertel and Foyle 1995).

2. Composition

a. Mineralogy

Terrigenous sands are predominantly quartz and feldspar and are low in carbonates (less than five percent) (Milliman 1972). However, there is a carbonate high off the Delmarva peninsula where the carbonate content reaches 50 percent (Figure 2-15).

The heavy mineral distribution of shelf sediments off Virginia have been studied in detail (Berquist 1990). Factor analysis has shown that the heavy mineral suite is very fine sand differs north and south of the Chesapeake Bay mouth (Calliari *et al.* 1990). Seventeen heavy minerals were identified. Seven minerals (zircon, sphene, amphibole, epidote, staurolite, pyroxene, garnet) were chosen for detailed analysis because previous work has shown these minerals to account for 96 percent of the heavy mineral variability in the lower Chesapeake Bay area. Heavy mineral assemblages comprised of these seven mineral (factors) were analyzed. In order of decreasing abundance, the Factor I assemblage was comprised primarily of amphibole, pyroxene, and epidote. The Factor II assemblage was comprised primarily of zircon, garnet, and amphibole. The Factor III assemblage was comprised primarily of garnet, amphibole, and epidote. The concentrations gradients of the three factors relative to the heavy mineral fraction are shown in Figures 2-52, 2-53, and 2-54. The Factor III assemblage characterizes the shelf north of Chesapeake Bay while Factor II is more abundant south of the bay entrance.

b. Trace Metals

The concentration of nine trace metals (barium, cadmium, chromium, copper, iron, lead, nickel, vanadium, zinc) in surficial sediments off the Delmarva peninsula are included in Appendix B. Concentrations generally correlate with the abundance of fine grained sediment and are low compared to average crustal rocks (Bothner 1979). It should be noted that the areas sampled in Bothner (1979) did not include known areas of waste disposal or other anthropogenic point sources of metals on the continental shelf.

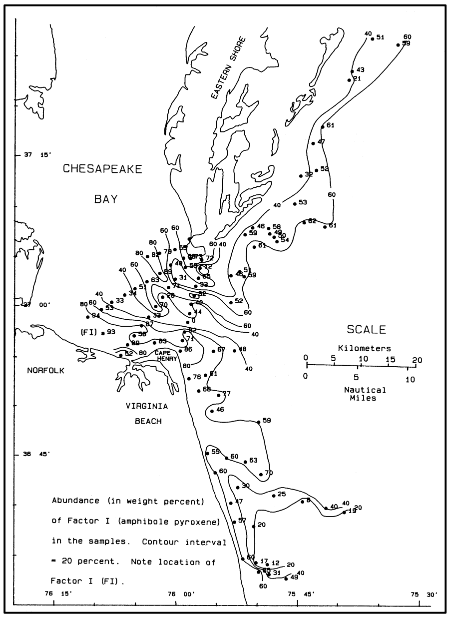


Figure 2-52. Abundance of Factor I heavy minerals assemblage in Virginia continental shelf and Chesapeake Bay entrance (from Calliari *et al.* 1990).

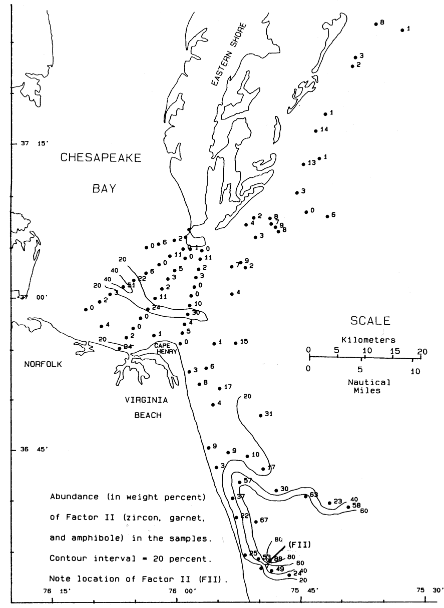


Figure 2-53. Abundance of Factor II heavy minerals assemblage in Virginia continental shelf and Chesapeake Bay entrance (from Calliari *et al.* 1990).

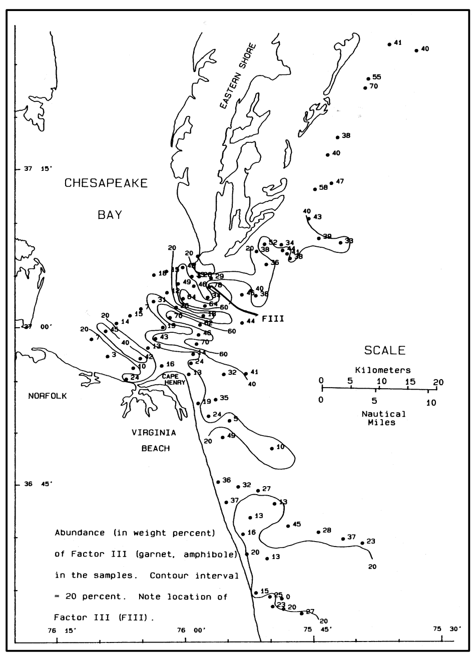


Figure 2-54. Abundance of Factor III heavy minerals assemblage in Virginia continental shelf and Chesapeake Bay entrance (from Calliari *et al.* 1990).

Major oxide and minor element concentrations of heavy mineral bulk sediments and magnetic fractions from the

Virginia shelf are presented without interpretation in Berquist (1990). The distribution of iron oxide on the continental shelf is presented in Appendix B. The occurrence and degree of iron staining of grains decreases with decreasing grain size (Milliman 1972). The distribution of the iron stained fine sand fraction of continental shelf sediments is shown in Figure 2-19.

B. Identified Offshore Sand Resources

Surficial and subsurface sands are found as sheet sands, linear sand ridges, and paleochannel fills (Swift *et al.* 1977; Wright *et al.* 1987; Kimball *et al.* 1991; Hobbs 1997).

Williams (1987) evaluated sand resource potential off Virginia for beach nourishment in terms of four criteria:

> 1) The quartzose sand should be clean, with little or no silt and clay and with a minimum median grain diameter of 0.20 mm (fine sand). The optimum grain size to best match the native beach sediment appears to be 0.30 to 0.35 mm; however, slightly finer sediment may apparently be used if the overfill ratios are increased.
>
> 2) The sand deposits should be shallower than 19.2 meters (63 feet) below sea level, the maximum depth of dredging for deepening the Atlantic Ocean Channel.
>
> 3) The sand stratum should be a minimum of 0.61 meters (two feet) in thickness.
>
> 4) The sand should not have more than 0.61 meters (two feet) of undesirable fine-grained sediment overburden.

Suitable sand reserves might be found in the numerous ridge fields identified on the Virginia continental shelf (*e.g.*, the False Cape Ridge field). However, economic and technologic factors of sand dredging and sand emplacement favor the targeting of potential reserves near the beaches requiring nourishment. Thus, Virginia has focused its investigation of offshore sand reserves on Sandbridge Shoal and paleochannel systems near the Virginia Beach Resort Strip.

Sandbridge Shoal

Sandbridge Shoal, opposite Sandbridge, is a horseshoe shaped shoal partly in Federal waters (Figure 2-55). Kimball and Dame (1989) identified Sandbridge Shoal as a potential source of beach nourishment sand. Additional data were subsequently acquired to further assess the resource potential of Sandbridge Shoal (Kimball *et al.* 1991; Hardaway *et al.* 1995).

The shoal is a northward and eastward thinning wedge of sand approximately 48 km^2 (18.5 square miles) in area and as much as 6 meters (20 feet) thick. The eastern and western limbs are separated by a swale. The western limb is characterized by a ridge and swale topography with a relief as great as four meters. The eastern limb is characterized by a low, undulating surface one to three meters in relief. Seismic records indicate Sandbridge Shoal overlies a paleochannel system.

a. Texture

Sandbridge Shoal is comprised of two sand units (Figure 2-56, Figure 2-57). separated by a thin sandy silt and clayey silt layer throughout much of the shoal. The upper unit (QH2) is a clean, well sorted medium

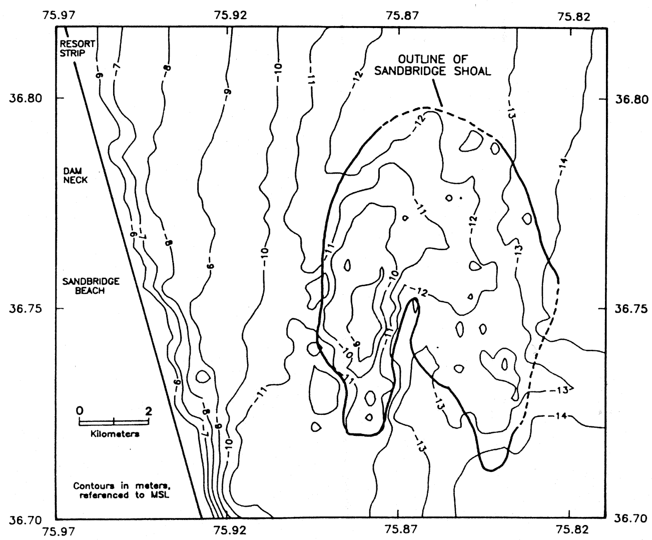
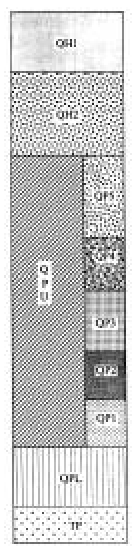


Figure 2-55. Detailed bathymetry showing outline of Sandbridge Shoal (from Kimball *et al.* 1991).



QH1 – Holocene sand sheet. Dark gray fine to very fine micaceous sand. Some coarser layers indicating storm sequences.
QH2 – Upper unit of Sandbridge Shoal. Olive gray, clean, well sorted, medium to coarse sand. In general coarsens upward.
QPU – Upper Pleistocene valley-fill sequence.
QP5 – Lower unit of Sandbridge Shoal. Slightly darker and finer than QH2.
QP4 – Clay and silt interpreted as estuarine.
QP3 – Gray, clean, well sorted, medium to coarse sand. Silty layers and gravely towards upper contact.
QP2 – Dark gray fine sand. Interpreted as bay-mouth or tidal shoal due to its relationship with QP3.
QP1 – Clay and silty clay. Interpreted as estuarine.
QPL – Lower Pleistocene valley-fill sequence.
TP – Interpreted as Pliocene. Defined by deep channel boundaries.

Figure 2-56. Generalized stratigraphic section of the inner shelf of southern VA (from Kimball *et al.* 1991).

to coarse sand. The mean grain size is 0.35 mm (1.5 phi) with generally less than 3 percent fines. This unit is usually olive gray becoming darker with depth. Surface sediments coarsen to the north and east. Gravel highs occur in the northeast (Figure 2-58).

The underlying lower unit (QP5) is a medium to fine sand that fines downward to a silty fine sand. This unit is present throughout the western half of the shoal but thins and outcrops along its borders. A seismic reflector representing a five centimeter thick sandy silt and clayey silt layer separates the upper and lower sand units throughout most of the shoal. The lower sand has a sharp, continuous contact with an underlying shell hash layer 10 to 25 centimeters thick.

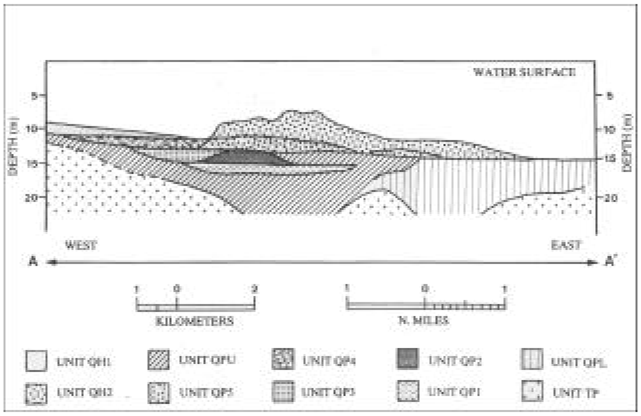


Figure 2-57. Schematic interpretation of cross section along Segment A-A' on Figure 2-59 (from Kimball *et al.* 1991).

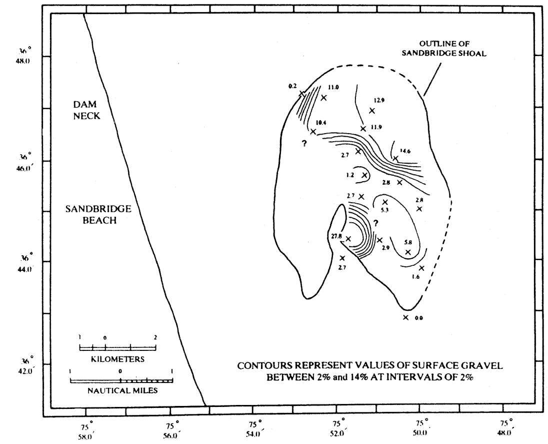


Figure 2-58. Contour map of percent gravel found in surface grab samples off Sandbridge Beach, Virginia (from Kimball *et al.* 1991).

b. Resource Potential

A means of assessing sand resource potential is to calculate the overfill factor and the periodic renourishment factor (James 1975; USACE 1984, 1995). These ratios compare native beach sand and borrow area sand grain sizes and erosion rates. Values calculated by Kimball and Dame (1989) indicate that the sand from Sandbridge Shoal is an excellent source of sand for the renourishment of southeast Virginia beaches.

c. Volume

There are varying estimates of the quantity of sand reserves at Sandbridge Shoal. The upper sand unit averages 2.5 to three meters (7.5 to ten feet) in thickness and reaches six meters (20 feet) thick in places. The lower sand unit varies between one and two meters (three to six feet) in thickness. A combined volume of both units is estimated by Kimball *et al.* (1991) as 8×10^7 cubic meters. Hardaway *et al.* (1995) estimated that Sandbridge Shoal may contain 30×10^6 cubic meters (40×10^6 cubic yards) of sand or less.

2. Paleochannel Fills

Three paleochannel systems have been identified on the Virginia shelf between Cape Henry and False Cape (Chen *et al.* 1995) (Figure 2-49). The geometry of these systems and their deposits are indicated in Table 2-8. Hardaway *et al.* (1995) describe paleochannel fills offshore the Virginia Beach Resort Strip and Rudee Inlet that appear to be related to the system described in Chen *et al.* (1995) off of Rudee Inlet. Hobbs (1997) describes paleochannel fills recognized from seismic data offshore Sandbridge (Figure 2-50).

Two paleochannels underlying Sandbridge Shoal are described in Kimball *et al.* (1991) (Figure 2-59). The fill units associated with these channels (QPU and QPL) extend beyond the lateral limits of Sandbridge Shoal. Both units outcrop at the surface. The younger channel (QPU) is estimated to have been 4.5 kilometers wide. The older channel (QPL) is estimated to have been two kilometers wide.

Table 2-8. Geometry of the Paleochannel Systems

System	Relative Relief	Axial Depth	Main Stem Width
III	2 to 4	-14 to -20	50 to 80
	(<1 to 5)	(-12 to -24)	(max 200)
II	4 to 6	-18 to -22	100 to 400
	(<1 to 8)	(-15 to -24)	(max 600)
I	9 to 12	-24 to -30	200 to 600
	(<1 to 14)	(-15 to -31)	(max 1000)

All values are meters.
Parenthetical values ( ) indicate extreme values.
Axial depth is (approximate) distance below sea level.
(from Chen *et al.* 1995)

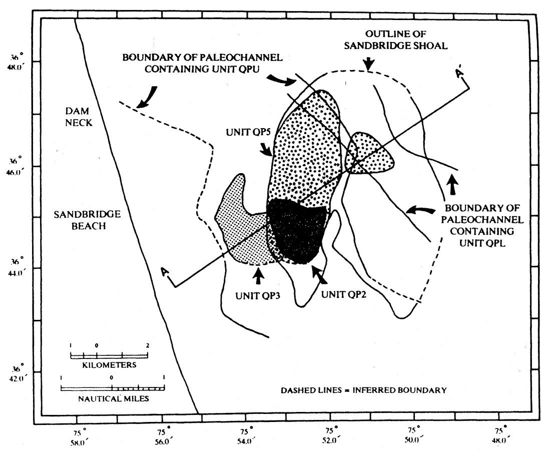


Figure 2-59. Areal relationships of major stratigraphic units off Sandbridge Beach, Virginia. See Figures 2-57 and 2-58 (from Kimball *et al.* 1991).

a. Texture

The sediment textures of channel fills are variable. The channel deposits described by Hardaway *et al.* (1995) off the Virginia Beach Resort Strip consist of fine to coarse sands and gravels at various depths. Core logs presented in Kimball *et al.* (1991) illustrate the variability of channel fill texture. In a core from Sandbridge Shoal, the QPU unit is reached at 3.75 meters depth, underlying 2 meters of shoal sand and 1.75 meters of estuarine clay and silt. The QPU unit here fines with depth from a muddy, medium to coarse sand interbedded with silty clay to a silty fine to very fine sand with silt lenses. At another location outside the limits of the shoal sands, QPU is reached beneath the estuarine clay and silt at just over one meter depth. Here, the channel fill is described as clay and silty clay with a thin layer (5 cm) of fine sand and silty clay at a depth of 5.5 meters.

b. Resource Potential

Overall, paleochannel fill deposits vary in grain size, depth, and thickness. The coring program off the Virginia Beach Resort Strip reported in Hardaway *et al.* (1995) suggests there lies a great potential for channel fill deposits to serve as a source of beach nourishment sands. Two cores contained thick channel fill units (11 feet and 14 feet) of coarse sand and gravel. The sands meet the Williams (1987) criteria cited above that units be at least two feet thick with less than 0.61 meters (two feet) of overburden; have a median sand size coarser than fine sand; and be situated in waters depths under 19.2 meters (63 feet). Site specific seismic and core data are needed to better assess the potential of known paleochannel fills to be used for beach nourishment.

c. Volume

Hardaway *et al.* (1995) calculated that the channel fill represented by the two cores mentioned above would yield about 3 x 10^6 cubic meters (4 x 10^6 cubic yards) of sand suitable as beach fill if it is assumed that the unit is continuous for about 5 km (3 nautical miles) between the two cores with an average channel width of 150 meters (500 feet) and average thickness of 3.7 meters (12 feet).

2.2.3 Climate

The coastal maritime weather of the study area is characterized by a climate of extremes typical of the Mid-Atlantic region with hot summers and cold, stormy winters. Offshore air temperatures for the New York Bight area range from a mean low in February of 1º C to a high in July of 22º C. Extreme hourly temperatures have been recorded at –19º C to 34º C. Weather conditions are variable in the fall and winter with a series of storms producing strong winds and high seas; weather conditions are more stable in the summer. Prevailing winds in the fall and winter tend to be out of the northwest, but stormy nor'easters can occur. These two to three-day northeast storms produce severe conditions offshore with high winds, cold rain, and steep seas due to the open fetch to the northeast. Prevailing winds in the summer are southerly, increasing in mid-morning to rarely greater than 20 knots and usually dying down at dusk. The area experiences considerable rainfall throughout the year with a slight seasonal low in the winter months. Mean monthly precipitation ranges from about three to 4.5 inches. Offshore fog is uncommon, but can be produced during spring when a warm moist southerly flow of air passes over cold ocean water.

Winds in the study area are an important influence on the physical environment since they generate surface waves and affect the water column characteristics and flow throughout the waters on the continental shelf (Beardsley *et al.* 1976a). The breakdown of the water column thermal stratification, which occurs in the fall, is in large part forced by the storm winds produced of the fall.

Wind speeds are the strongest during the fall and winter months with winds exceeding 30 knots greater than 5 percent of the time in November, December, January, and February. Wind speeds peak in December when winds exceed 30 knots more than 6 percent of the time. During these months, the predominant wind direction is out of the northwest. During March and April, winds are more southerly but still strong. March winds exceed 30 knots nearly 5 percent of the time. The most common occurrence of high waves is in March and December. Long period swells (wave periods exceeding 12.5 seconds) result from either severe local storms or storms offshore in the North Atlantic. Long period swells occur most often in the spring and in the October to December period.

The average current flow over the continental shelf of the New York Bight is toward the south-southwest at about 5 cm/s near the surface. These currents decrease to about 1 cm/s near the bottom (Mayer *et al.* 1979). These currents are forced by intense low pressure systems in the winter. However, the occurrence of energetic wind-driven transient current events, primarily during the winter months, significantly alter the mean flow pattern.

2.2.3.1 Storms Along the Mid-Atlantic Coast

Storms that affect the mid-Atlantic coast consist primarily of hurricanes and extratropical storms (also referred to as nor'easters) (*e.g.*, Dolan, *et al.* 1988). Coastal erosion resulting from either one of these two types of storms depends on a variety of parameters such as topography, shoreline orientation to waves, and the specifics of each storm (speed, intensity, size, duration, track). A brief discussion on both types of storm systems follows.

Hurricanes

Hurricanes form in the tropics and generate high winds and wave heights. Compared to nor'easters, hurricanes move comparatively quickly; their impacts are strong but are usually limited to a comparatively small area in the vicinity of the point of landfall (Jones and Davis 1995). Hurricane season is between June and October. The effect of passing hurricanes is a function of distance to the shore, tidal elevation at the time of passage, direction and speed of movement of the hurricane.

In the mid-Atlantic states, hurricanes that make landfall are rare. Only six hurricanes of any category hit the coastline between 1900 and 1996, of which only one was a major hurricane (Table 2-9). Most of the hurricanes affecting the mid-Atlantic states move north or northeastward with their centers either located off the coast or inside the coast after having made landfall further south. The most severe hurricanes affecting the mid-Atlantic states are hurricanes that move inland over eastern North Carolina (Dunn and Miller 1960).

Extratropical Storms or Nor'easters

Nor'easters occur far more frequently than hurricanes. The winds and wave heights are lower than during hurricanes, but nor'easters generally move slower and cover a considerably larger area. Therefore, although less intense, they are responsible for much of the damage along the open-ocean beaches along the mid-Atlantic coast (*e.g.*, Mather *et al*. 1964).

Dolan and Davis (1992) investigated 1,347 storms between 1942 and 1984 and devised a five-stage intensity scale for nor'easters for the mid-Atlantic coast, based on wave hindcasts from Cape Hatteras. The threshold for a storm was a deep-water wave height of 5 feet (1.6 m), which can result in measurable beach face erosion. The characteristic wave heights and duration of such storms are presented in Table 2-10; the typical coastal impacts of these storms are presented in Table 2-11.

The total number of Class I to Class V storms from 1942 to 1992 ranged from 20 to 48 storms per year; the average number of Class IV and Class V storms ranged from zero to three storms per year (Jones and Davis 1995; Figure 2-60). The highest number of nor'easters occurred between October and April; the lowest number occurred in the summer from June to August (Figure 2-61). A total of 32 Class IV storms and seven Class V were recorded in the 43-year period between 1942 and 1984. The severe Class V storms occurred in October and between January and March.

Class IV and V storms commonly form in two areas in the south, Florida and Cuba. They are typically blocked by a strong pressure system in the north which slows their advance and extends the presence of the storm in the mid-Atlantic region, causing the development of a long fetch over the open ocean (Dolan and Davis 1992; Davis, *et al.* 1993).

Table 2-9.
Number of Hurricanes Direct Hits on the Mainland U.S. Coastline by State, 1900-1996(*)

State		**New Jersey**	**Delaware**	**Maryland**	**Virginia**	**North Carolina**
***Category** (**)*	1	1	0	0	2	10
	2	0	0	1	1	4
	3	0	0	0	1	10
	4	0	0	0	0	1
	5	0	0	0	0	0
	Total (1,2,3,4,5)	**1**	**0**	**1**	**4**	**25**
	Major Hurr. (3,4,5)	***0***	***0***	***0***	***1***	***11***
***Month of Major Hurricanes** (Categories 3,4,5)*	June	0	0	0	0	0
	July	0	0	0	0	0
	August	0	0	0	0	2
	September	0	0	0	1	8
	October	0	0	0	0	1

(*) North Carolina was added since the most of the hurricanes affecting the project area make landfall in eastern North Carolina. (Dunn and Miller 1960).

(**) Categories are based on the Saffir/Simpson Scale (Simpson and Riehl 1981):

Category	*Wind (mph)*	*Surge (feet)*	*Damage*
1	74-95	4-5	Minimal
2	96-110	6-8	Moderate
3	111-130	9-12	Extensive
4	131-155	13-18	Extreme
5	>155	>18	Catastrophic

Source: National Hurricane Center 1999.

Two of the most severe storms along the mid-Atlantic coast over the last 50 years were the Ash Wednesday storm in March 1962 and the Halloween storm in October 1991. During the Halloween storm, deep-water wave heights of up to 34 feet (10.7 meters) were recorded off Cape Hatteras, and erosional wave heights of more than five feet (1.6 meters) occurred for 114 hours (Davis and Dolan 1992). Maa and Wang (1995) reported wave heights of 26.2 feet (8 meters) at a wave station 100 km off the Virginia coast. The tremendous strength of the Halloween storm was partially caused by added energy from Hurricane Grace which was located in the open Atlantic.

Table 2-10.
Characteristics of Five Storm Classes (*)

Storm Class	**Frequency**		**Deep-Water Significant Wave Height** (m)		**Duration** (hr)	
	No.	%	Mean	st. dev.	Mean	st. dev
I Weak	670	49.7	2.0	0.3	8	4.3
II Moderate	340	25.2	2.5	0.5	18	7.0
III Significant	298	22.1	3.3	0.7	34	17
IV Severe	32	2.4	5.0	0.9	63	26
V Extreme	7	0.1	7.0	1.3	96	47
Total	1,347	100				

(*) The data are derived from storms that occurred between 1942 and 1984, hindcasted from Cape Hatteras.

Source: Dolan and Davis 1992.

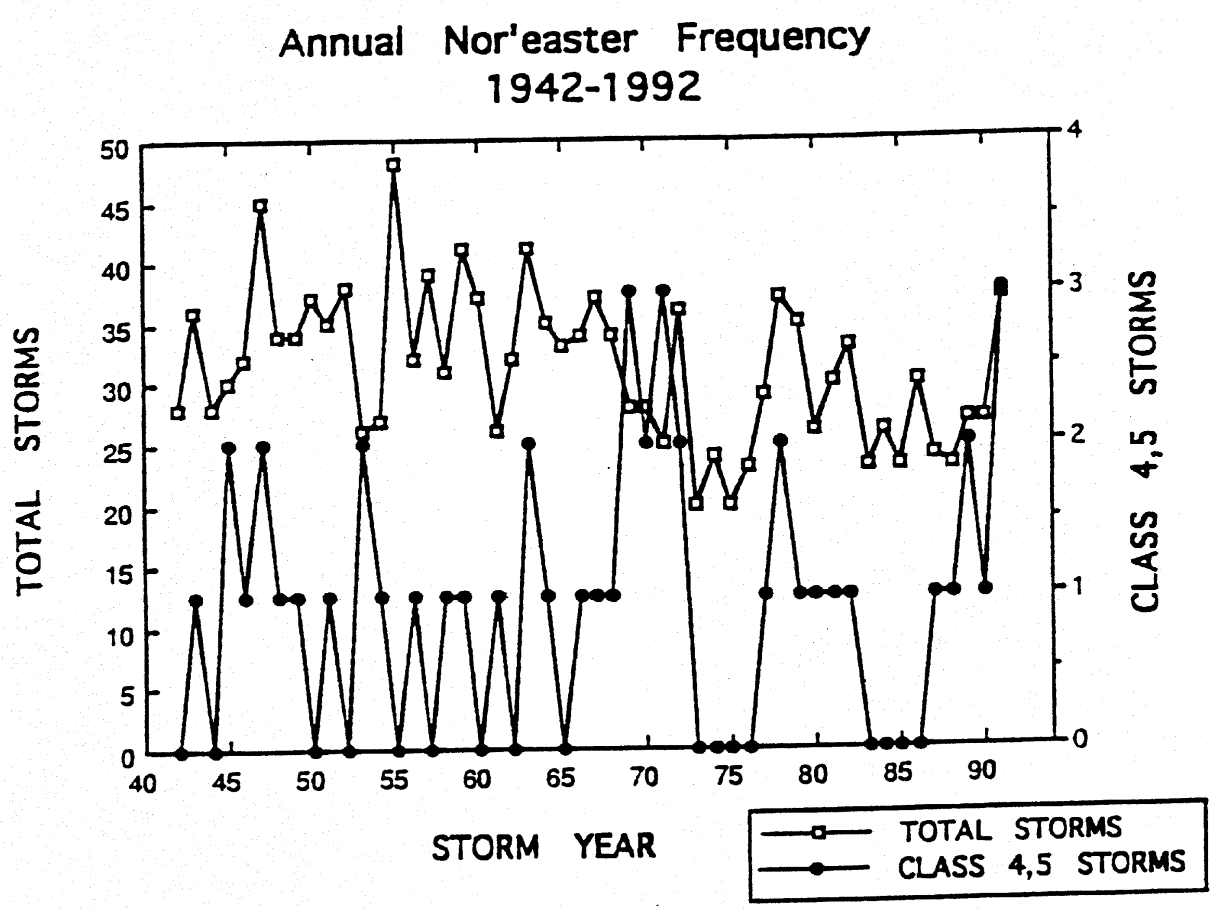
Table 2-11.
Storm Classes and Coastal Impacts

Storm Class	Beach Erosion	Beach Recovery	Property Damage	Dune Erosion	Dune Breaching	Overwash	Inlet Formation
I Weak	Minor changes	Full and usually immediate	No	None	No	No	No
II Moderate	Modest: confined to lower beach	Full	Minor, local	None	No	No	No
III Significant	Erosion: extends across entire beach	Usually recovery over considerable period of time (months)	Loss of many structures at local scale	Can be significant	No	On low profile	No
IV Severe	Severe beach erosion and recession	Recovery seldom total	Losses of structures at community level	Severe dune erosion or destruction	Where beach is narrow	On low profile beaches	Occasionally
V Extreme	Extreme beach erosion (up to 50 m in places)	Permanent and clearly noticeable changes	Extensive regional scales: millions of dollars	Dune destroyed over extensive areas	Widespread	Massive in sheets and channels	Common

Source: Dolan and Davis 1992.

Figure 2-60.

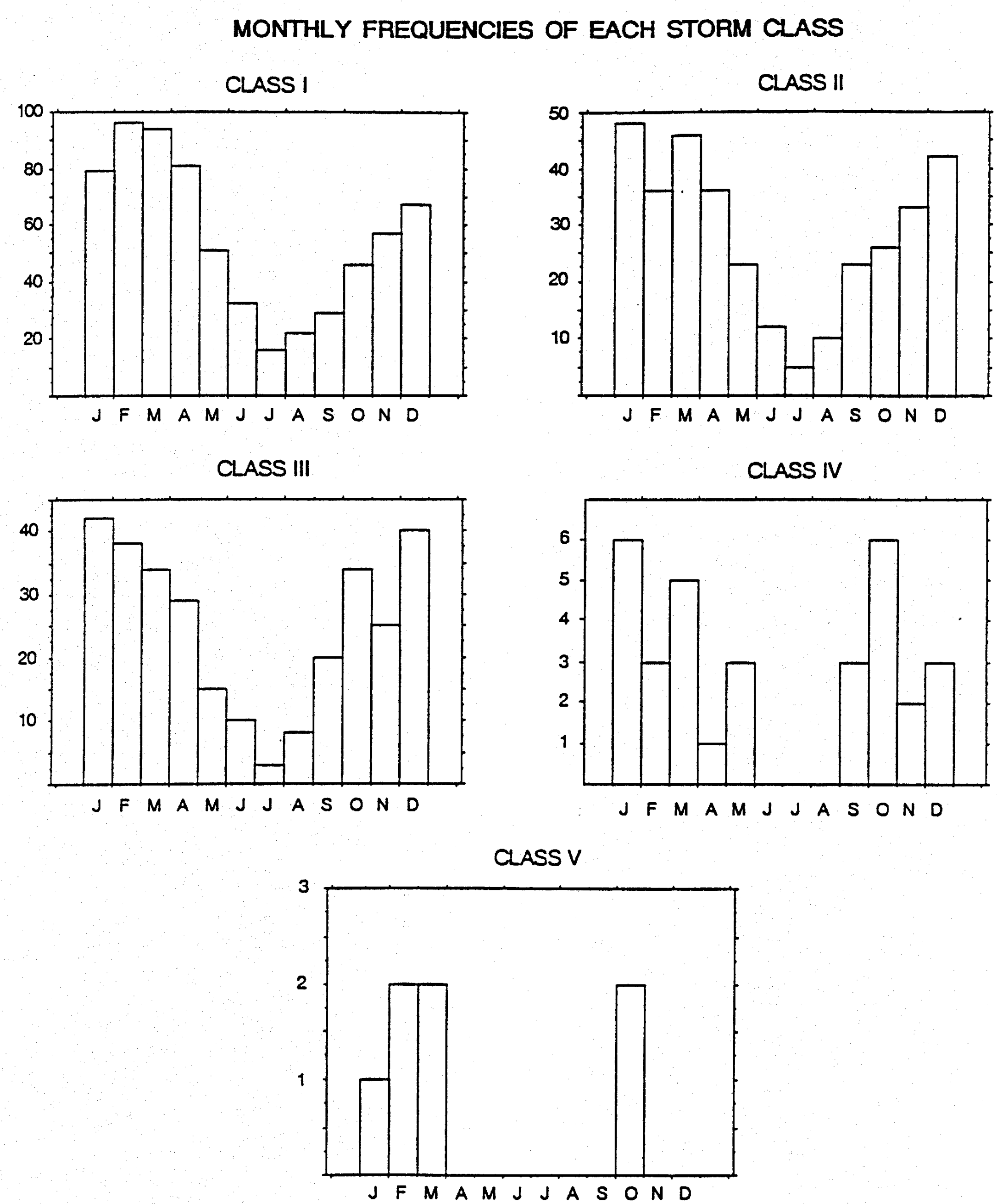
Annual Nor'easter Frequencies of Total Storms (Class I to V) and Class IV and V Storms for 1942-1992



Source: Jones and Davis 1995.

Figure 2-61.

Monthly Frequency of each Storm Class (Class I to V) based on 1,347 Storms between 1942 and 1984



Source: Dolan and Davis 1992.

2.2.4 Air Quality

Ambient Air Quality Standards

The U.S. Environmental Protection Agency (EPA) defines ambient air in 40 CFR, Part 50, as "that portion of the atmosphere, external to buildings, to which the general public has access," in compliance with the 1970 Clean Air Act (CAA) and the 1990 Amendments (CAAA). EPA has promulgated ambient air quality standards and regulations. The National Ambient Air Quality Standards (NAAQS) were enacted for the protection of public health and welfare, allowing for an adequate margin of safety. To date, the EPA has issued NAAQS for six criteria pollutants: carbon monoxide (CO), sulfur dioxide (SO_2), particulates with a diameter less than or equal to a nominal 10 micrometers (PM_{10}), ozone (O_3), nitrogen dioxide (NO_2) and lead (Pb). There are two types of standards: primary and secondary. Primary standards are designed to protect sensitive segments of the public from adverse health effects which may result from exposure to criteria pollutants. Secondary standards are designed to protect the environment from any known or anticipated adverse effects of a pollutant, including the effects on the natural environment (soil, water, vegetation) and the manmade environment (physical structures). Areas that do not meet the NAAQS are called nonattainment areas; areas that meet both sets of criteria are known as attainment areas. EPA also has recently established new NAAQS for ozone and fine particulate. For ozone, the current one-hour standard will eventually be supplanted by a new eight-hour standard. The standard for PM_{10} will remain essentially unchanged, and a new standard for particulate matter less than or equal to 2.5 microns ($PM_{2.5}$) is established. After the new standards were finalized by the EPA in July 1997, the EPA needs to determine classification of areas with respect to the new 8-hour standard by July 2000. Once regions are classified, states with nonattainment areas must submit by the year 2003 for EPA approval a State Implementation Plan (SIP) that provides for the attainment and maintenance of the standards through control programs. National standards for ambient air quality are presented in Table 2-12.

Air Pollutants Concerned in the Study Area

The emission sources of those "criteria pollutants" regulated by the NAAQS are of concern nationally, statewide and regionally. In general, ambient concentrations of carbon monoxide (CO) are predominantly influenced by mobile source emissions; emissions of sulfur dioxide are associated mainly with stationary sources; ozone (O_3), lead (Pb), nitrogen oxides (NO_x), volatile organic compounds (VOCs) and particulates (PM_{10}) come from both mobile and stationary sources. The relationship and major concern between these criteria pollutants and the proposed project activities can be described below.

Ozone, a colorless gas, is a major constituent of photochemical smog at the earth's surface. At medium concentration levels, ozone can cause eye irritations; at high concentration levels, ozone can create severe respiratory problems. The precursors in the formation of ozone are VOCs and NO_x. In the presence of sunlight, ozone is formed through a series of chemical reactions that take place in the atmosphere. Because the reactions occur as the pollutants are diffusing downwind, elevated ozone levels are often found many miles from sources of the precursor pollutants. Ozone concentrations at ground level are usually highest during hot summer afternoons when the photochemical activity is most pronounced. Ambient ozone concentrations are products of local precursors and long-range transport of ozone and its precursors from upwind sources. Thus, the effects of ozone precursors emissions from the project activities are usually examined on a regional or mesoscale basis, especially for the summer time. Since the study area encompasses several states - New Jersey, Delaware, Maryland, and Virginia, the impacts of a specific project's activities (mainly resulting from the operation of dredging, pump-out equipment, dredge propulsion engines, and tugs or barges) need to be studied for various attainment, nonattainment, or maintenance areas. The most concerned areas for O_3 and its precursors include the Monmouth, Ocean, and

Table 2–12.
National Ambient Air Quality Standards

Pollutant	Primary	Secondary
Carbon Monoxide (CO)		
1-hour Average	35 ppm	35 ppm
8-hour Average	9 ppm	9 ppm
Sulfur Dioxide (SO_2)		
3-hour Average		1300 :g/m^3
24-hour Average	365 :g/m^3	
Annual Arithmetic Mean	80 :g/m^3	
Particulates (PM_{10})		
24-hour	150 :g/m^3	150 :g/m^3
Annual Geometric Mean	50 :g/m^3	50 :g/m^3
Particulates ($PM_{2.5}$)		
24-hour	65 :g/m^3	65 :g/m^3
Annual Geometric Mean	15 :g/m^3	15 :g/m^3
Ozone (O_3)		
1-hour Average	0.12 ppm	0.12 ppm
8-hour Average	0.08 ppm	0.08 ppm
Nitrogen Dioxide (NO_2)		
Annual Arithmetic Mean	100 :g/m^3	100 :g/m^3
Lead (Pb)		
Quarterly Average	1.5 :g/m^3	1.5 :g/m^3

Notes:

ppm = parts per million
:g/m^3 = micrograms per cubic meter

Annual standards never to be exceeded; short-term standards not to be exceeded more than once per year.
Source: Code of Federal Regulations Title 40, Part 50, July, 1991, "Ambient Air Quality Standards".

Burlington Counties in New Jersey; the Kent County in Delaware, and the Virginia Beach and Norfolk Counties in Virginia.

Carbon monoxide is also a colorless and odorless gas that results from the incomplete combustion of gasoline and other fossil fuels. In most parts of the country, approximately 80 percent of CO emissions are from motor vehicles. Because CO disperses quickly, the concentrations can vary greatly over relatively short distances. Elevated concentrations are usually limited to locations near crowded intersections and along heavily congested roadways. Since beach nourishment projects will generally not increase CO emissions near roadways or intersections and will not cause any major concerns for CO concentrations, further localized analysis is not required.

Inhalable particulates (PM_{10}) are emitted from various sources: industrial facilities, power plants, construction activity and diesel-powered vehicles. These particulates are less than 10 micrometers (:m) in diameter and, therefore, inhalable. Since the beach nourishment projects will not emit measurable PM_{10} pollutants, detailed analyses are not required.

Sulfur dioxide (SO_2) emissions are primarily associated with the combustion of sulfur-containing fuels, oil and coal. No appreciable quantities of this pollutant are emitted from project-related sources. Therefore, analyses of potential impacts from SO_2 are not required.

Lead emissions are primarily associated with motor vehicles and industrial sources that use gasoline containing lead additives. All vehicles produced in the United States after 1980 are designed to use unleaded fuel, and the ambient air concentrations have declined significantly. Therefore, the analyses of lead emissions are not required.

Existing Compliance Status within the Study Area

The project site is located along the east coast states of New Jersey, Delaware, Maryland, and Virginia. The study areas within each state are:

- Monmouth, Ocean, Burlington, Atlantic, and Cape May Counties in New Jersey
- Kent and Sussex Counties in Delaware
- Worcester, Wicomico, and Somerset Counties in Maryland
- Accomack, Northampton, Virginia Beach, and Norfolk Counties in Virginia.

While most of the corresponding onshore areas (COA) of the project are located in the attainment areas for the criteria air pollutants, the existing compliance status vary from one area to another. The entire study area is within the EPA designated attainment for five criteria pollutants: CO, SO_2, Pb, NO_x, PM_{10}. No exceedances of NAAQS are found within the proposed project study areas for these pollutants.

The ozone (O_3) compliance status varies from county to county. In summary, Monmouth and Ocean Counties, New Jersey are classified as severe-17 nonattainment as included in the New York - North New Jersey - Long Island Area; Burlington County, New Jersey as included in the Philadelphia - Wilmington - Trenton Area is designated as severe-15 nonattainment; Atlantic and Cape May Counties, New Jersey are currently not subject to 1-hour O_3 standard because of the improvements (previously designated as moderate nonattainment) and their status regarding 8-hour O_3 standard will be determined in the year 2000.

In Delaware, Kent County is designated as severe-15 O_3 nonattainment as part of Philadelphia - Wilmington - Trenton Area; while Sussex County has been improved and the 1-hour O_3 standard no longer applies

(previously designated as marginal nonattainment), while attainment for 8-hour O_3 standard will be determined in 2000.

Maryland counties (Worcester, Wicomico, and Somerset), as parts of Air Quality Control Region (AQCR) 114 - Eastern Shore Interstate Area, have been designated by the EPA as in O_3 attainment.

The coastal areas in Virginia, within the AQCR 224 - NE Virginia Intrastate area including Accomack and Northampton Counties, are also designated by the EPA as in O_3 attainment; while the Virginia Beach and Norfolk Counties as parts of the Hampton Roads Area are classified as O_3 maintenance areas (previously designated as marginal nonattainment).

In summary, the major compliance concerns for the study area are (1) the O_3 nonattainment issues which would involve the proposed projects in conformity determination for various SIPs, and (2) the large portion of project sites located within the national Ozone Transport Region (OTR), including New Jersey, Delaware, and Maryland, which would force potential projects to undergo more restrictive rules and emission thresholds. For example, within a severe nonattainment area, the threshold is 25 tons/year for NO_x and VOC. For a moderate or marginal nonattainment area within an OTR, the threshold is 100 tons/year for NO_x and 50 tons/year for VOC. Any project emissions that exceed these thresholds are subject to the General Conformity Rules in 40 CFR 93.

State Implementation Plan (SIP) in Nonattainment Areas

To achieve the attainment for ozone, each state which contains nonattainment area is required to establish the SIPs and the Maintenance Plans once the area is redesignated to attainment to control and reduce potential emissions, such as NO_x and VOC. All projects proposed in these areas should follow the SIP or Maintenance Plan, and all federally sponsored or approved projects have to meet the Conformity Rules of Federal Actions to conform with the SIPs (40 CFR Parts 6, 51, and 93). Furthermore, for the areas within an OTR, special mandatory CAA measures need to be followed.

To achieve and maintain the attainment status, all proposed project activities should be operated by following the requirements indicated in the SIPs or Maintenance Plans including the New Jersey SIPs, the Delaware SIPs, and the Virginia Maintenance Plans to ensure the air quality will continue to meet standards in the future.

2.2.5 Physical Oceanography

2.2.5.1 Water Masses

Three types of water masses are present over the continental shelf in the Middle Atlantic Bight: (1) coastal or shelf water subject to large seasonal variations, (2) slope water having characteristics defined by mixing of shelf water with open ocean water masses, and (3) Gulf Stream water. Shelf water originates from the coastal waters off Canada where it moves southward over the continental shelf. Shelf water is continuously modified by river runoff and air-sea interaction as it moves to the south. In winter, the temperature of the shelf water mass is much lower compared with that of the slope water mass due to the cooling effects by the atmosphere (Figure 2-62). Salinity of shelf water, influenced by freshwater runoff is generally lower compared with offshore water masses.

Currents in the shelf water mass have a stronger southwest-directed component in the winter season compared to all other seasons. Development of the shelf water mass along the Mid-Atlantic coast is also

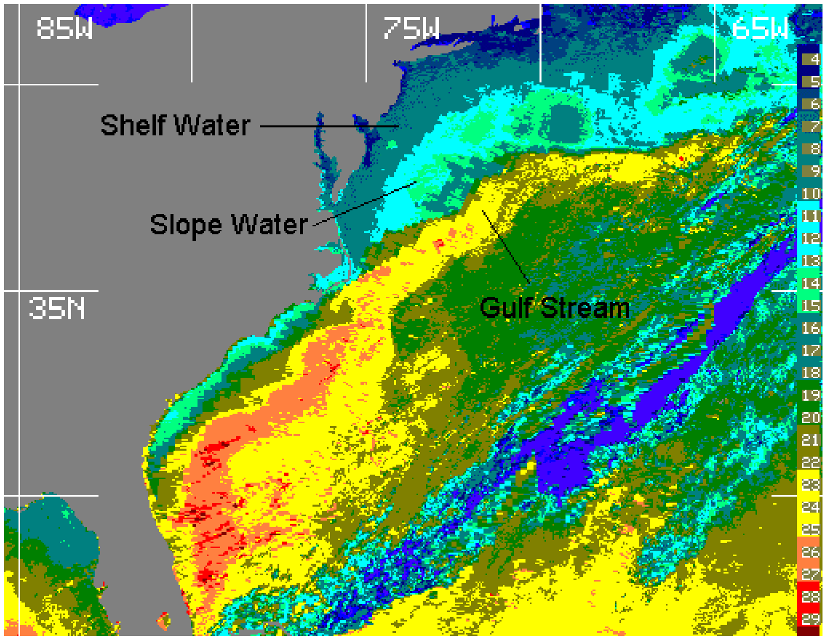


Figure 2-62. AVHRR satellite image showing winter temperature differences among water masses in the Mid-Atlantic region. Legend at right is in degrees C.

dependent on the variations in Gulf Stream transport from the south, as well as on atmospheric forcing and river runoff. Currents paralleling the coast vary in magnitude from 5 to 20 cm/sec. Some portions of the shelf water mass following the coast can be deflected towards the open sea at the Hudson Canyon (northern or eastern cell). Other portions of the shelf water mass can move along the coastline down to Cape Hatteras and then turn seaward in direction (southern or western cell). These two cells form cyclonic gyres. Thus, from a time-averaged point of view, regional shelf circulation is characterized by a two-celled gyre system.

The water influenced by the northern cell, extending from the Nantucket Shoal to Hudson Canyon, moves towards Massachusetts and Rhode Island and then turns to seaward. It eventually joins a compensating offshore drift, which occurs east of the Hudson Canyon. In the southern cell, unlike the northern cell, the water experiences very few intrusions from offshore. Inflow to this cell comes primarily from rivers along coast. It has been shown from the results of dye experiments that weak cyclonic eddies exist near the New Jersey coast during the summer and autumn. It is possible that within 40 nautical miles from shore, a reversal of the surface current occurs due to the southerly wind or as a result of lower river runoff.

The slope water mass can be defined as a mixing zone for shelf water and Gulf Stream water. The slope water mass is more oceanic compared with shelf water. The temperature-salinity (T-S) characteristics of slope water are between those of shelf water and Gulf Stream water. Below 200m depth the slope water mass can be identified as slightly fresher compared to the waters of the central North Atlantic Ocean. However, at a depth of approximately 900m the slope water mass becomes indistinguishable from North Atlantic Deep Water. The circulation patterns of the slope water, seaward of the shelf break, have not been studied in detail. However, observations indicate that currents are directed southward to Cape Hatteras and then turn seaward. The slope water may have a cyclonic gyre motion reaching speeds in the range of 10 to 40 cm/sec. In this region the surface circulation tends to be a cyclonic gyre similar to circulation of the shelf water. The outer area of slope water merges into the Gulf Stream zone. Observations have shown that a number of warm anticyclonic eddies may develop throughout the year in the slope water mass, although the general slope water circulation is in a cyclonic motion. These eddies are formed when a Gulf Stream meander becomes unstable, detaches from main Gulf Stream, and is then entrained into the slope water (Figure 2-63).

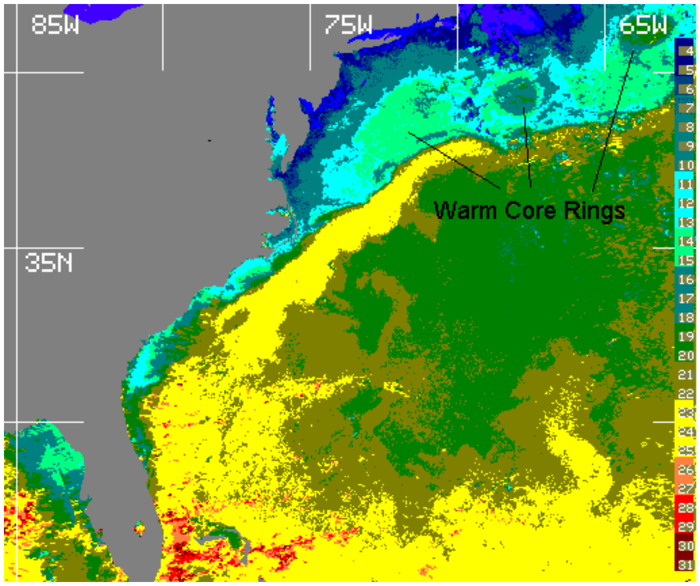


Figure 2-63. AVHRR satellite image showing warm core rings drifting into the slope water mass. Legend at right is in degrees C.

Water exchanges and transfers between the surface slope water and shelf water are well known. The major exchange takes place south of Rhode Island along the 200m contour line. The evidence for water exchanges at the boundary between the slope and shelf waters is marked by a temperature inversion near the shelf break. This inversion develops as the shelf water overrides the edge of the slope water mass. This situation persists until mid-autumn, when diffusion processes and overturning break down the inversion.

The Gulf Stream originates from northwest of Little Bahama Bank and becomes stronger as it moves northward. The Gulf Stream parallels the continental margin, and in vicinity of Cape Hatteras, it shifts seaward away from the margin and heads into the open ocean (Figures 2-62 and 2-63). The Gulf Stream is a permanent feature without major directional shifts throughout the year. However, the surface speed varies seasonally from as little as 10 cm/sec in winter to as high as 2 m/sec in summer. After leaving the continental shelf, the Gulf Stream acquires meandering motions (Figure 2-62). Meandering can result in the warm core rings moving to the north of the main axis of the Gulf Stream (Figure 2-63) and the cold core rings moving east and south of the Gulf Stream. The warm core rings frequently drift into slope water zones.

2.2.5.2 Circulation Patterns

Coastal Currents

The general circulation patterns of the coastal ocean over the continental shelf of the Mid-Atlantic Bight have been known since the 1940's. Iselin (1940) recognized the basic pattern of nearshore circulation from the fundamental differences in the salinity regimes of oceanic and coastal waters. In oceanic waters, the salinity decreases with depth, partly counteracting the stability resulting from the vertical temperature gradient. In contrast, over the continental shelf the salinity concentration usually increases with depth. This implies that the coastal circulation has an offshore component at the surface and an inshore component beneath. Coastal water masses, because of freshwater influence from rivers, are at most times of year lighter compared with the corresponding layer offshore. The low salinity outflow from rivers and estuaries of the Mid-Atlantic region has provided a generating mechanism for this motion. As low salinity flows are introduced along the coast, the related pressure gradient from increased water elevation and hydraulic slope, in combination with the Coriolis Effect, results in a geostrophically balanced southward flow. However, this first order flow system is modified by thermohaline circulation and wind-driven forces. Over the years, drift bottles, seabed drifters, drift poles and parachute drogues indicate that there is a mean longshore flow on the order of 5 cm/s from Cape Cod to Cape Hatteras (*e.g.*, Miller 1952, Bumpus 1973).

Bumpus (1973) provided a general description of the coastal water circulation on the basis of drifter data compiled over a 12-year period. The winter surface circulation in the coastal ocean over the continental shelf consists of a southerly drift having an offshore component along the Middle Atlantic region (Figure 2-64). Surface drift over the continental slope are directed offshore and net drift over the lower continental rise is directed northeast paralleling bathymetric contours (Figure 2-64). The southerly surface drift off the Middle Atlantic region is well defined in the nearshore area during the autumn months and interrupted less often by reversals compared to the summer season. As the autumn season progresses, there are fewer returns from offshore, suggesting increases in the offshore component as the onset of winter approaches. During the summer months the observed surface drift to the southwest is more coast-parallel on the average and the net offshore drift over the outer continental shelf and slope weakens (Figure 2-65). Northeast direct surface drift over the continental rise is more persistent during the summer months according to drifter results (Figure 2-65).

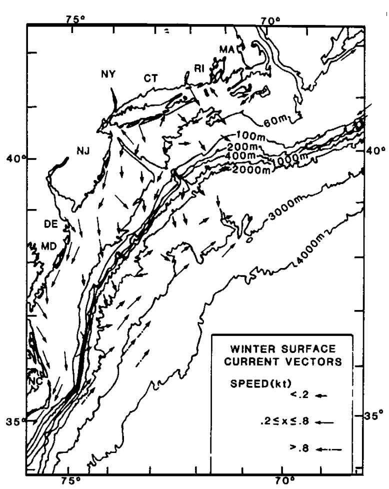


Figure 2-64. Winter surface drift patterns from drifter observations (Bumpus 1973, SAIC 1987)

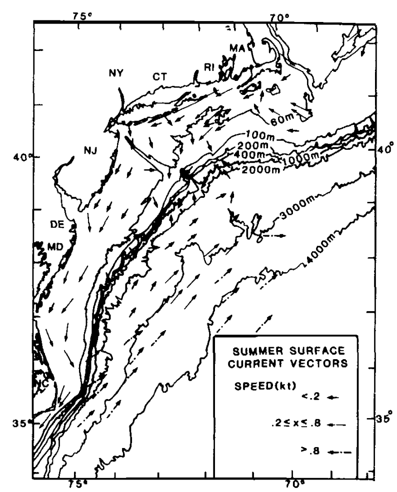


Figure 2-65. Summer surface drift patterns from drifter observations. (Bumpus 1973, SAIC 1987)

Major transfers take place between surface slope water and the shelf water. This was confirmed in several studies that examined the mixing process along the 100-fathom (182.9-meter) line south of Rhode Island (Miller 1950; Miller 1952; Bumpus 1965). Interpretation of relationships between temperature and salinity distributions and drifter trajectories indicates that southerly coastal drift consists of several distinct currents or eddies having branches and offshoots, merging or breaking away from general drift. Drifter experiments show that flow trajectories are along lines of similar salinity and temperature (Bumpus 1973). The contribution of individual estuarine systems of the southern New England to Mid-Atlantic Bight region to the coastal circulation can also be recognized (Wong 1998a, 1998b; MMS 1998). Individual systems can have an appreciable effect on the current pattern, due to the modification of the T-S distributions.

The escape of coastal water from shelf zone was observed by Ford and Miller (1952) and Ford *et al.* (1952) when they found a narrow discontinuous band of relatively cold and fresh water in the left margin of the Gulf Stream northeast of Cape Hatteras. This demonstrated that the southward flowing shelf water on the continental shelf turns eastward at Cape Hatteras and is entrained between the Gulf Stream and the slope water (Figure 2-66). Fisher (1972), as well as many others, also observed the entrainment of relatively cold, low salinity water by Gulf Stream. Ketchum and Corwin (1964) examined the pool of cold bottom water, extending from south of Long Island to off Chesapeake Bay. There was also evidence of “detaching”, in which a large bubble of cold water had separated from the core and moved seaward (Cresswell 1967).

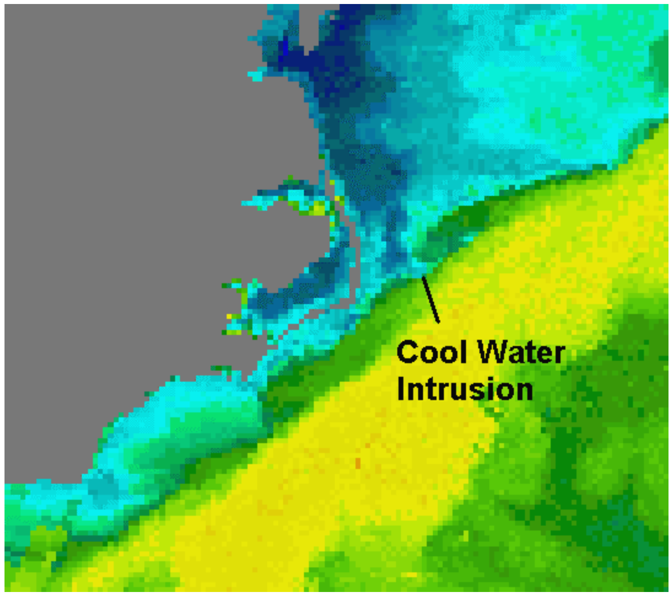


Figure 2-66. Intrusion of cooler water into the western boundary of the Gulf Stream off Cape Hatteras.

Wind-Driven Surface Circulation

Wind stress strongly influences the vertical T-S structure of the water column, as well as nearshore circulation in the shallower inner shelf portions of the project area. There are two major atmospheric pressure systems, the Bermuda High and the Icelandic Low, which control regional wind patterns. The Bermuda High, located in the subtropical gyre of the north Atlantic Ocean, produces southwesterly winds having daily average speeds of 1.5 to approximately 3 m/s off the eastern U.S. coast during the summer. In winter months, the Bermuda High system weakens and the Icelandic Low, located south of Greenland, brings air from the west and northwest. This atmospheric condition results in relatively strong mean wind speeds reaching a maximum daily average of between 3.6 to 4.6 m/s during January. Variability in the wind patterns within the study area is determined by variations in the features of Bermuda High and Icelandic Low atmospheric pressure systems at time scales of about 2 to 5 days. Another process influencing wind stress and resulting circulation is the impact of land air masses and the influx of the cold Labrador Sea water that episodically causes the local changes of wind patterns. Severe wind conditions can be generated by the thermal wind effect caused by the temperature difference as winds move over cold slope water to warmer Gulf Stream water.

The surface circulation in the Chesapeake Bight varies seasonally dependent upon river flow, the local winds, and the changes in the stability of the water. The prevailing surface drift in the Mid-Atlantic Bight is generally southerly. However, a northerly flow can develop in the summer when the water column is highly stratified and the southerly winds prevail. The surface wind can also change the structure of temperature and salinity. The maximum surface temperatures usually occur in August in the Mid-Atlantic Bight, but the maximum bottom temperature lags and occurs in September, October or even November (Bumpus 1957). The depression of sea surface temperature has been occasionally observed along the northeast coast of North Carolina in July and August following southwesterly winds (Wells and Grey 1960). This occurs episodically when offshore movements of the surface waters require subsequent replacement by upwelling of the cold water. Summer cool water upwelling events are most frequent during mid-July to September. Chase (1959) noted that these changes in the water temperature are the result of wind-driven advection rather than *in situ* modification of the water by the atmospheric processes. These changes also induce a rising and falling of the summer thermocline as the warm surface waters become thinner or thicker.

Slope Gyre

Between the northern wall of the Gulf Stream and shelf water, there is a strong velocity shear. In the shear zone between Cape Hatteras and Nantucket Shoals, an elongated cyclonic gyre of the slope water is generated by the stress of northward flowing Gulf Stream and the southwest flow of the coastal water (Figure 2-67). The shear zones separates the shelf water from the Gulf Stream during all seasons of the year. The slope water gyre is present approximately 85 percent of the year. Direct current measurements in slope water have shown a long-term average of surface currents on the order of 0.2 kt (10cm/s) to the southeast along the coast (Beardsley *et al.* 1976b). The permanent average flow in the coastal zone is southeast at all depths. Extensive studies by Bumpus (1973) of the permanent flow inshore the 100-m isobath indicate a mean flow on the order of 0.1kt (5cm/s) southwest from Nantucket Shoals to Cape Hatteras (see Figures 2-64 and 2-65). Williams and Godshall (1977) also observed a relatively strong southwest current of 5 cm/s along the New Jersey coast. A rough estimate of volume transport of longshore current is about 3 SV [1 Sverdrup (SV) = 10^6 m^3/s] from the Mid-Atlantic Slope and Rise Study (1987).

The slope gyre has a seasonal shift that is related to the position of the north wall of the Gulf Stream. The normal position of the north wall appears to move to the northeast during the winter months and is related to interaction of the Gulf Stream with cold and warm core rings in the Cape Hatteras region. This displacement of the Gulf Stream causes a shoreward shift in the location of the slope gyre and an extended penetration of the gyre toward the southwest.

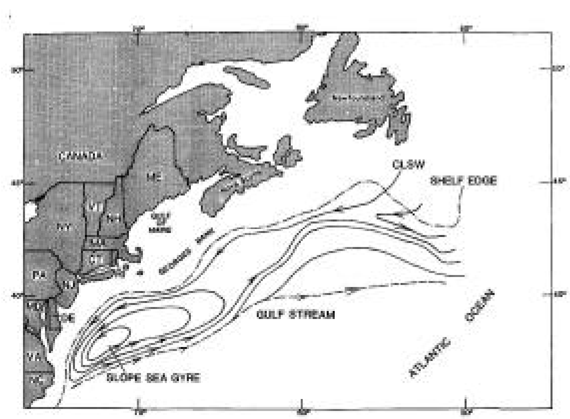


Figure 2-67. Slope water circulation pattern (from MMS 1989).

Gulf Stream

Whereas the Gulf Stream does not directly impact coastal and inner shelf circulation in the southern New England to Mid-Atlantic region, strong secondary impacts by the Gulf Stream on coastal circulation are important to consider. The strong volume and heat transport provided by the Gulf Stream produce density variations that have an important role in determining the regional circulation in the Mid-Atlantic area. The Gulf Stream plays an important role in transporting heat, momentum, and mass flux on the global scale. It flows with a mean speed of 1 m/s, at all times, and has the temporal dynamic variability on time scales ranging from two days to seasons and longer. The water volume transported to the northeast by the Gulf Stream is along the seaward flank of the slope gyre. The subsurface waters are exchanged with those of the slope gyre through isopycnal mixing. The location of the northern wall of the Gulf Stream in the open ocean varies with scale of the meandering motion and eddies (Figures 2-62 and 2-63).

The Gulf Stream system shows propagating, amplifying waves that are apparently driven to instability by the shear-flow process of baroclinic instability. The meandering results in detachments of entire rings, or loops of Gulf Stream water, to both the north and south, which can persist and migrate for many months (Figure 2-63). Satellite imagery derived from thermal infrared radiation (TIR) shows spatially growing waves and detached eddies in the adjacent Gulf Stream System (Figure 2-63). The eddies are termed rings when they enclose non-local water. Those to the north have warm cores, are anticyclonic, and generally contain large segments of Sargasso Sea water that have been pinched off during an extreme meander. Whereas the rings tend to lose their surface thermal contrast with respect to their surroundings as time goes on, nonlinear flow in the velocity structure persists for months, and the rings and eddies may have lifetimes on the order of one year.

The warm core rings in the smaller spatial area of the continental shelf and slope interact with topography and the Gulf Stream more often compared with cold core rings. This intense interaction results in a relative shorter lifetime for warm core rings (about 6 months) than for cold core rings (> 1 year). A net transfer of water on and off the continental shelf may result from the interaction of eddies and continental shelf waters. The role of the eddy in the slope water is known to push the oceanic water onto the shelf and to pull fresher water off the shelf (Flagg *et al.* 1992).

Tides

Semidiurnal forces characterize the tidal motion in the Mid-Atlantic Bight. Current meter observations (Griscom 1968) showed that semidiurnal tidal currents account for over 70 percent of the current variance at tidal frequencies. Energy peaks in spectra of motion at tidal frequencies in the Mid-Atlantic area occur at the semidiurnal and diurnal frequency of tidal motions. Spectral and harmonic analysis of tides also indicates that the amplitude of the semidiurnal peaks increase shoreward across the shelf (NOS 1985). Figure 2-68 shows a generalization of the Principal Lunar Semidiurnal (M^2) tide. The tidal amplitude and co-tide lines (line of equal phase) for the Atlantic Ocean are derived from a global tidal model described by Schwideriski (1979). Shown are two amphodromic points around which the semidiurnal tide travels in a counter-clockwise direction at a period of 12.42 hours. In the western Atlantic Ocean in areas offshore of the mid-Atlantic region, the M^2 tide has amplitude of 0.25 meters (0.82 feet). Tidal constituents of secondary importance include the semidiurnal solar tide (S^2) and the diurnal lunar tide (O^1), each having an amplitude of approximately 25 to 30 percent of the dominant M^2 tide.

In the shallow areas near the coast, amplitudes of tidal constituents are greatly amplified along with the associated tidal currents. Figure 2-69 compares the predicted tides at two locations on the coast in the mid-Atlantic area for the same four-day period in March 1999. The mean tidal range at the coast varies from more than 4 feet at the entrance to New York Harbor to just over two feet at Cape Hatteras, NC.

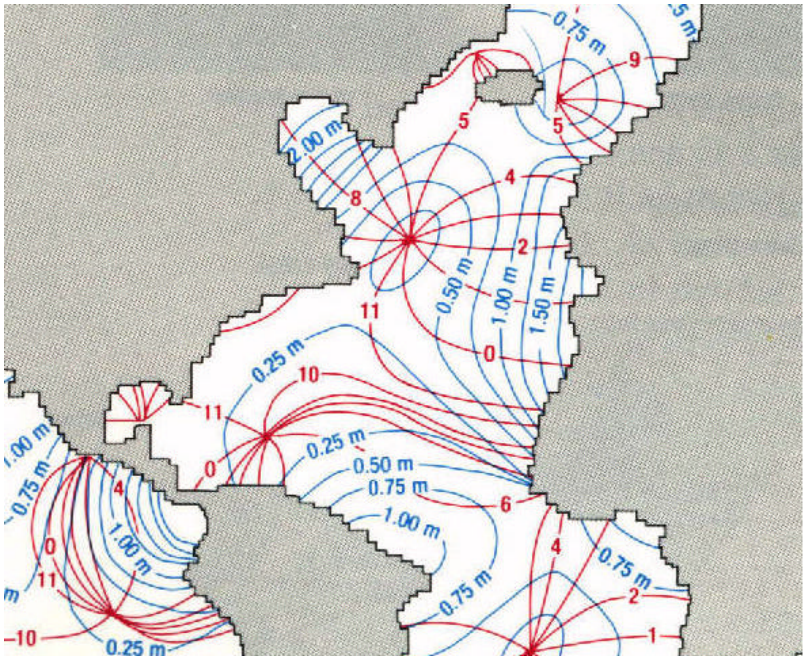


Figure 2-68. Amplitude of the M[2] tidal constituent in the Atlantic basin and co-tidal lines (from Schwideriski 1979).

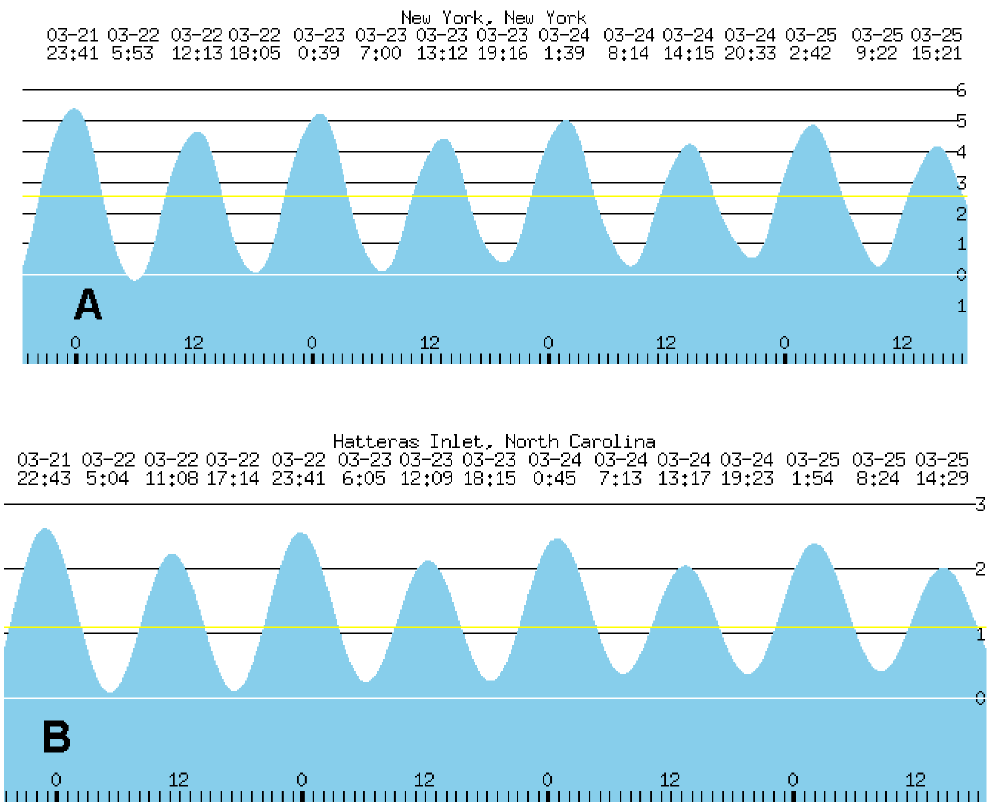


Figure 2-69. Comparison of predicted tides at A) New York Harbor entrance and B) Cape Hatteras between March 21 and March 25, 1999. Vertical scale on the right hand side is in feet.

In offshore areas greater than 30 feet in depth, tidal currents are weak, generally less than 5 cm/sec, and contribute only a small portion to observed currents. Offshore, where bottom stress has a reduced effect, the tidal wave propagation tidal currents are rotary. However, nearshore tidal currents are bi-directional and rectilinear if confined in inlet and estuarine channels were current speed can exceed 3 ft/sec.

2.2.5.3 Water Mass Characteristics

Water masses are classified according to temperature and salinity characteristics, which provides a method for tracking circulation of the deep water, or water having low frequency motion. In shallow coastal waters and transitional waters, the situation can be more complex than that found in the deep ocean because local river drainage, exchanges of flux through sea surface and biological activities result in strong physical and chemical variability. In the mid-Atlantic region, surface temperatures range from approximately 3.0°C to nearly 26.0°C at maximum. The horizontal distribution of the sea-surface temperature exhibits a zonal pattern year-round, being lower in the coastal zone compared to offshore areas. This pattern also reflects to some degree the latitudinal effects of increasing temperature with decreasing latitude.

Large horizontal gradients of temperature are observed from December through March, along with variability that increases toward the southeast over the Mid-Atlantic Bight as the slope water is encountered. The seasonal variability of temperature is marked in the coastal zone over the continental shelf due to intrusion of the slope water. The standard deviation of the surface temperature is at a minimum in August, uniform over the area, and highest in the southeast. The high standard deviation of temperature in the southeastern part of the area is probably the result of the perturbations in slope fronts. The temperature and salinity front delineated at the region of the shelf break along 100 meters (328.1 feet) depth separates the fresher shelf water from more saline slope water.

The salinity distribution in the nearshore coastal zone influences the density distribution, and it is often used as a tracer in determining the horizontal or vertical mixing rate due to the conservative characteristics of salinity. A conservative property denotes that there is no assumed change in the volume except by flux of material in or out. The salinity regime of continental shelf water masses is controlled by river runoff and by influx of the saline oceanic water. The seasonal trends of salinity distribution, like temperature, is also forced by the cycle of the river discharge having a maximum in April and May. The salinity maximum of shelf waters occurs during the winter months when values of surface salinity reach 33 ppt across the midshelf and 34 ppt at the shelf break. The salinity minimum in continental shelf waters occurs in summer when salinity values drop into the 32-33 ppt range, having a time lag with river runoff.

The density structure of the continental shelf water is similar to the salinity structure, increasing with depth and seaward throughout year. Density is lowered near the coast by the discharge of fresh river water and low salinity estuarine water. Water of higher density is essentially oceanic water at the eastern boundary of the continental shelf. Maximum density is observed in late winter, resulting from low temperatures and high salinity, and minimum density is observed in summer, resulting from high temperatures and low salinity. The density front at the shelf-slope water interface is maintained by salinity since the effect of salinity on density overrides the effect of temperature.

As summer progresses, the seasonal thermocline intensifies and very complex temperature structures develop on spatial scales of tens of kilometers. A marked thermocline develops in summer on the inner continental shelf at depths of 15 to 20 m, where temperatures as low as 7-8 °C occur in the pool of residual “winter” water. At depths of 10 m, summer vertical stratification is evident, with small variability of temperatures above 10 m due to penetration of short wave radiation and conversion to thermal energy. The variance of the temperature is large at the 50 m layer, which implies the existence of internal waves along the density interface between warmer surface layers and subsurface layers, as well as active exchanges between continental slope water and shelf water.

The vertical structure of salinity in summer includes a strong salinity front at the shelf break, separating the coastal water, influenced by river drainage having salinity of less than 33 ppt, from slope water having salinity of more than 35 ppt. The density slope front in summer results primarily from the salinity structure rather than from the temperature structure, and is characterized showing an upward bulge of isopycnals at the shelf break indicating a possible upwelling motion. The slope of isopycnals on the shelf can produce the geostrophic flow to the southwest, which is in good agreement with observations of mean flows (Bumpus 1973).

In the fall season, from September to October, the surface temperature drops, but the bottom temperature continues to rise. By late October to November, strong surface cooling and wind forcing overturns the water column and destroys the thermocline over the continental shelf. In winter, the maximum shelf water temperatures are observed in the layer between 100 m and 200 m, and minimum water temperatures occur in the top layer where temperatures range from 3 to 10 °C. The winter temperature structure consists of nearly homogeneous water on the shelf and of a thermal front along the shelf break where it is steeply inclined. Water temperature in the frontal area increases by 4 °C over a distance of 20 nmi, and increases vertically at the shelf break from about 9 °C at the surface to 11 °C at the bottom. Here, temperature inversions occurring in the bottom layers can produce southward flows on the bottom along the shelf break. Increases in water temperature greater than 10 °C indicates intrusion of slope water at the shelf-slope front. The horizontal temperature gradients over the shelf in winter are nearly normal to the coastline, with mean temperature increasing seaward, from less than 5 °C near the coast to a range of 5 - 7 °C across most of shelf, and rising abruptly at the shelf-slope water front.

During winter, the surface cooling by sensible heat loss (*i.e.*, by convection and conduction) takes place over the shallow areas of the continental shelf and can extend to the bottom layer so that the winter-cooled shelf water, which is defined as 8 °C or less, generated at the bottom can persist in some areas into the summer. The warm core water having temperatures exceeding 14 °C may be detached from the Gulf System in water along the shelf break from Maryland and northward (Figure 2-63).

2.2.5.4 Ocean Waves

Ocean wave processes that affect the Mid-Atlantic area can be described in three major categories according to physical processes and atmospheric response scales. Each major category can be correlated with depth zones and roughly with distance from the shoreline. When reviewing possible interactions among waves, boundary layer, and sediment transport processes in later sections of this report it is important to clearly recognize differences in spatial scales, time scales, and the type of air-sea interactions that take place in each zone. The statistical descriptions compiled from forecasts, hindcasts and direct measurements of waves can be reviewed with respect to possible impacts within the three main categories of wave processes. First, in the deep ocean, which defines the seaward limits of the study area, air-sea interaction provides the primary source of energy for waves that will eventually impact likely borrow areas closer to shore. Here, at depths greater than 200 meters, the spatial scale of response to imposed atmospheric processes (winds stress and atmospheric pressure gradient) extends over several hundred miles or more, at time scale greater than six to 12 hours. Air-sea interaction in the deep ocean along the Mid-Atlantic area is determined by the dominant wind patterns derived from interaction of the two semi-permanent pressure centers that control atmospheric pressure gradients and thus, winds in the Mid-Atlantic region. The Bermuda High, which is located in the subtropical gyre of the North Atlantic produces southwesterly winds in the summer months having average speeds of two to three m/sec in mid-summer. Conversely, in the winter months, the Bermuda High system weakens and shifts to the south and the Icelandic Low pressure system, located to the south of Greenland dominates weather patterns in the north Atlantic. Winds in the western Atlantic

Ocean are westerly to northwesterly, having average speeds of three to five m/sec in mid-winter.

Figures 2-70 and 2-71 show the regional distribution of wind wave patterns in the North Atlantic predicted to occur over a seven-day period in March 1999. The predicted patterns and changes over this period are typical of what can be expected during winter months. Large waves generated well out into the Atlantic, south of Iceland, can exceed 10 feet in height. Waves along the Atlantic coast can be the result of swells arriving from distal generation areas in the deep ocean. In the Mid-Atlantic region, waves heights under typical fair-weather conditions are in the range of two to three feet nearshore and three to six feet further offshore (Figure 2-70). However, the local wave field in the Mid-Atlantic area is also affected by passing regional pressure systems, as shown in Figures 2-70 and 2-71.

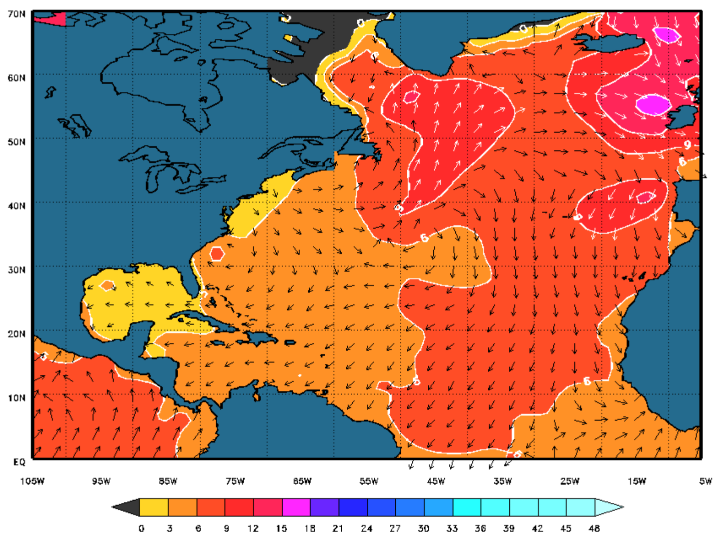


Figure 2-70. Predicted wave heights and wave directions from the Fleet Numerical Ocean Command WAM model for mid-day March 21, 1999.

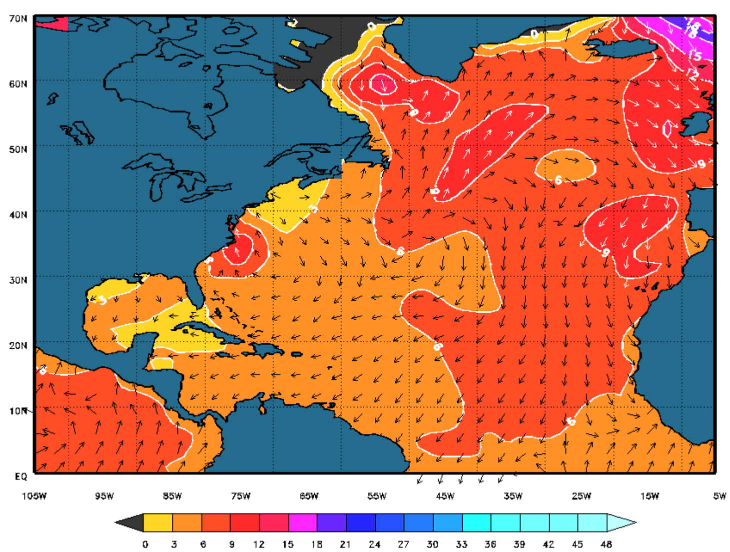


Figure 2-71. Predicted distribution of wave height and wave direction for midnight March 27, 1999. Note large wave heights predicted to occur off the mid-Atlantic coast of the U.S.

The wave field over the continental shelf area is determined by deep ocean waves that propagate across the shelf, as well as mesoscale features in response to atmospheric forcing at spatial scales of up to 100 miles. Response time to variations in atmospheric forcing is on the order of three to six hours. The observed wave field, moving over depths of 50 meters over the mid- to outer continental shelf will be influenced by bottom friction and wave transformation when moving to the inner continental shelf over depths of about 25 meters or less. The wave statistics on the mid- to inner continental shelf of the Mid-Atlantic region have been described from direct observations from the NOAA Buoy program and from wave hindcast simulations completed by the WES Coastal Hydraulics Laboratory (CHL). Comparisons of wave statistics developed by the CHL Wave Information System (WIS) hindcasts agree well with statistics from measured data such as NOAA buoys. Figure 2-72 shows the location of buoys from which wave statistics have been compiled over the past few years. These data can be used to make comparisons among subsections of the Mid-Atlantic region as well as to observe seasonal variations in the wave climate.

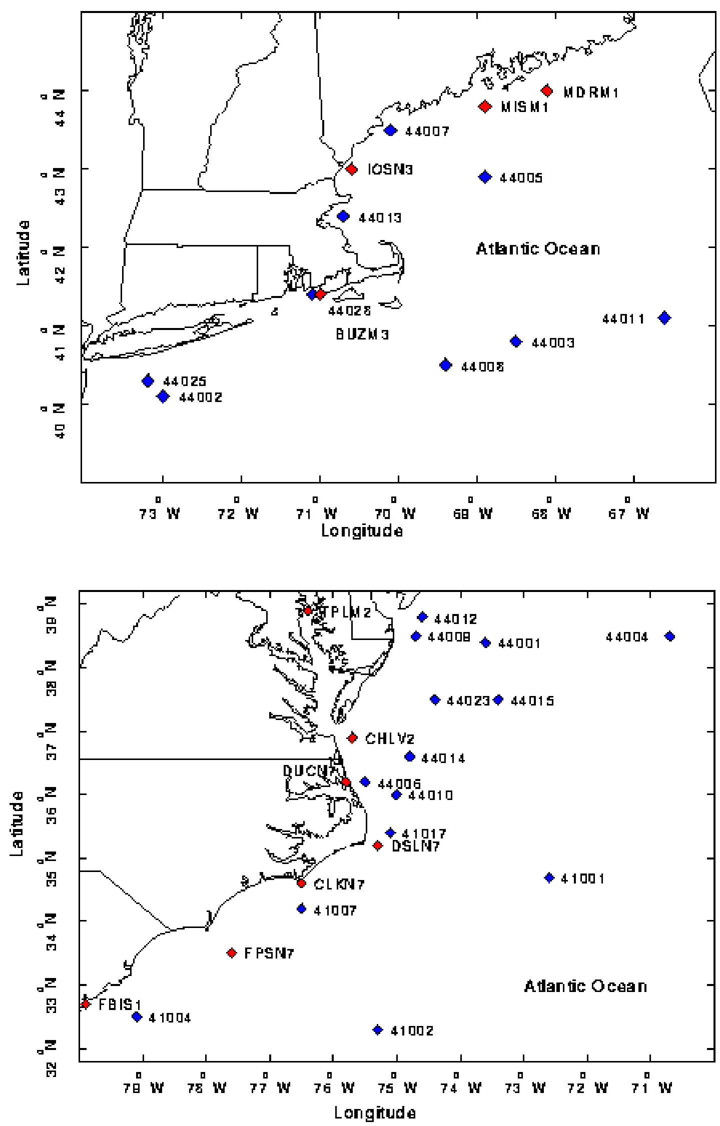


Figure 2-72. Location of NOAA environmental monitoring buoys on the Mid-Atlantic Continental Shelf.

A comparison of directional wave statistics from 1996 from NOAA Buoy 44025 off the Long Island, NY Coast at the northern edge of the study area and Buoy 44001 (Figure 2-72) off the entrance to Delaware Bay in the middle of the study area illustrates some regional and seasonal differences in wave regime. Figure 2-73 shows monthly mean wave heights and standard deviations for Station 44025 for years 1991 to 1993. Figure 2-74 provides the same data summary for Station 44001 off of Delaware Bay for the period 1986 to 1993. Data from both stations indicate a strong seasonal signal with respect to wave height and standard deviation. During the summer months, significant wave heights at both stations are below two meters and have relatively low standard deviations. During the mid-winter months, Station 44001 is clearly

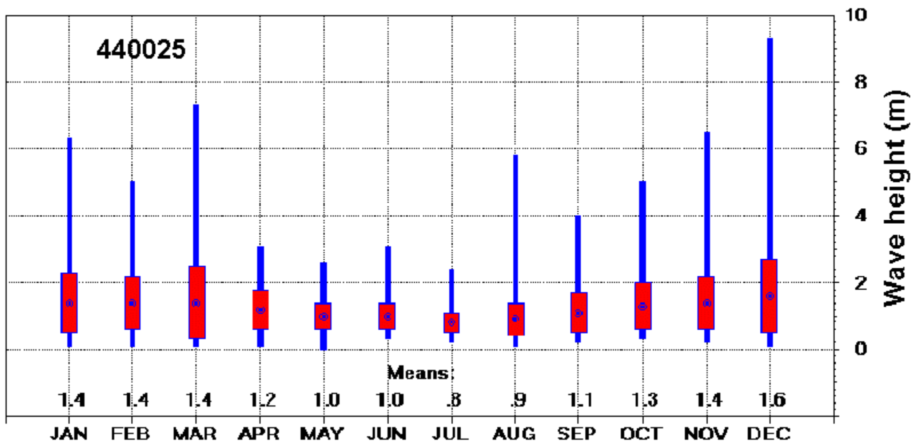


Figure 2-73. Monthly mean significant wave height based on data collected at NOAA Buoy 44025 south of Long Island (see Figure 2-72 for location).

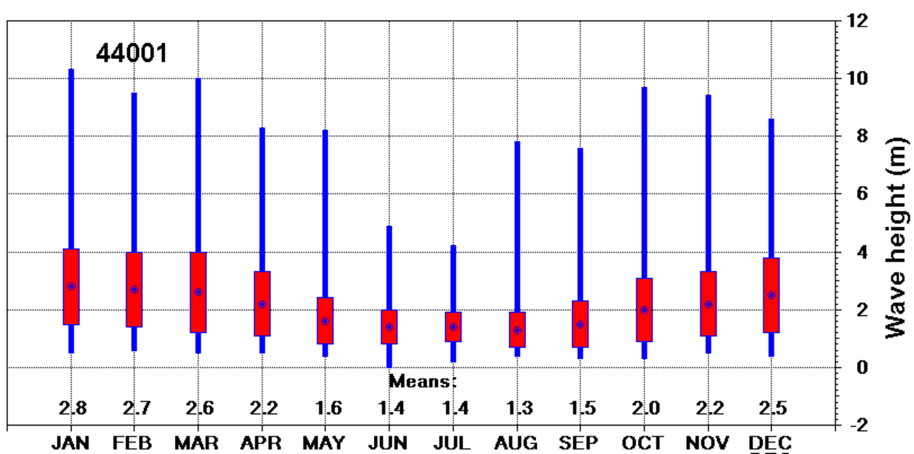


Figure 2-74. Monthly mean significant wave height based on data collected at NOAA Buoy 44001 southeast of Delaware Bay (see Figure 2-72 for location).

the more energetic station, having significant wave heights between three and four meters and a range of up to eight to 10 meters. Significant wave heights at Station 44025 average between 1 and 2 meters during the mid-winter months and have a maximum range in height well below Station 44001. Station 44025 is closer to shore and protected by the orientation of Long Island from full exposure to the high waves generated in the North Atlantic and wind waves generated more locally by winter northeaster storms.

In the nearshore zone at depths of approximately 15 meters and less, wave processes are strongly influenced by shoaling effects, oscillation of water levels at tidal and transient frequency, and wave-current interaction. Spatial scales for response to atmospheric conditions are generally less than 10 miles and response time is rapid and typically less than three hours. Since the local wave field is strongly influenced by shoaling transformations over local topography at short time scales, numerical simulations of wave spectra and statistics are limited to small areas due to the required spatial resolution. Thus, wave hindcasting and forecasting over large areas, very near the shoreline at depths of 10 meters, is not practical as yet. However, various coastal observation programs have provided long term reliable data from which statistics on significant wave heights, period and direction can be obtained. Wave data collected by the Network for Engineering Monitoring of the Ocean (NEMO)[1] maintained by the WES Coastal Hydraulics Laboratory (CHL) and Scripps Institute of Oceanography can be used to summarize spatial and temporal variations at several location along the Mid-Atlantic shoreline. Figures 2-75 and 2-76 compare the record of significant wave height and dominant direction measured at stations located in the coastal waters of Long Island, NY and Cape Hatteras, NC, respectively.

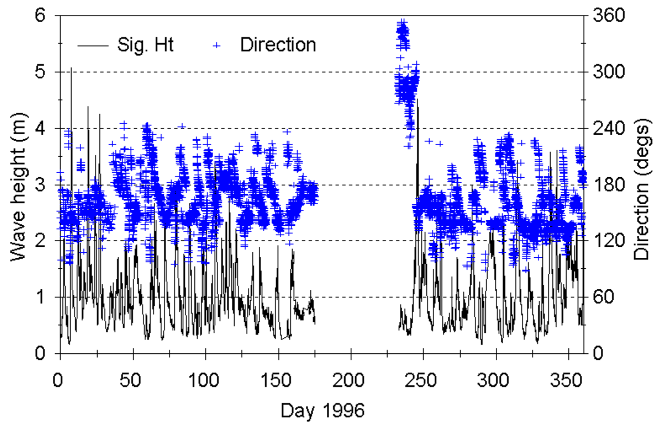


Figure 2-75. Significant wave height and peak direction recorded at a nearshore station at Westhampton, Long Island, NY in 1996.

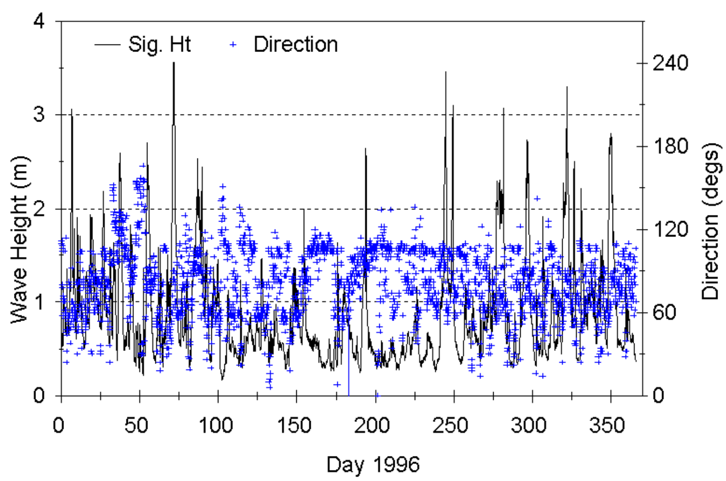


Figure 2-76. Significant wave height and peak direction recorded at a nearshore station at Cape Hatteras in 1996.

Both stations are moored very close to the shoreline in a water depth of approximately 10 meters. Similar to the offshore stations, seasonal differences in wave statistics are apparent, but significant wave heights are much lower at the Hatteras Station. Figures 2-75 and 2-76 included wave statistics for wave measurements at intervals of one

[1] The Network for Engineering Monitoring of the Ocean (NEMO) consists of several stations at various locations along the coastline of the United States. Parameters recorded are date, time (UTC), significant wave height (H_{mo}), wave period (T_p), wave direction (D_p), and depth.

to six hours and therefore provide a detailed record of storm impact as well as seasonal trends. Both stations show minimum average significant wave heights during the summer months (Days 172 to 264), except for missing data for the Westhampton station, and peak average wave heights during late fall to early spring months. These seasonal trends are punctuated by episodes of extreme wave energy related to storms. Under these conditions, due to northeasters in the winter and occasional tropical storms in the summer, wave heights can reach or exceed three meters at each station.

2.2.6 Water Quality

The water quality issues of primary concern with offshore dredging operations are mainly associated with turbidity. Additional water quality issues of importance are related to dissolved oxygen concentrations and resuspended contaminated sediments.

2.2.6.1 Turbidity

Natural turbidity (or suspended matter concentrations) in the water column of the ocean varies depending on the sea state. Comparatively low concentrations exist during calm periods. Turbidity increases during storms, particularly at the ocean floor. Impacts from offshore dredging operations need to be weighed against natural conditions. Therefore, following below is a brief discussion on the natural variability of turbidity on the Mid-Atlantic shelf waters.

Existing concentrations of suspended matter in the Mid-Atlantic shelf waters are typically low and vary between surface and bottom waters, between different seasons due to potential stratification in the water column, and in different areas due to different sources and grain sizes. A detailed study of the total suspended matter concentrations in the surface water along the shelf was conducted by Manheim *et al.* (1970). Concentrations measured seaward of the 3-mile zone were generally less than 1 mg/l. Closer to shore, the particulate matter consisted mostly of terrigenous matter; further seaward it consisted of mostly amorphous organic particles and plankton. The authors observed that suspended sediment discharged by rivers and estuaries travel largely longshoreward rather than seaward.

The conditions observed by Manheim *et al.* (1970) reflect calm weather conditions. Suspended matter concentrations are higher during storms. An example are data collected 20 km off the Cape Canaveral in Florida; although outside the study area, conditions apply also to the Mid-Atlantic shelf. The suspended matter concentration in the surface water was seven mg/l two days after Hurricane Betsy in September 1965; one month earlier the concentrations was 0.25 mg/l during calm weather (Manheim *et al*. 1970).

Total suspended matter concentrations collected during four different times in the fall of 1973 in the New York Bight were less than 2.0 mg/l seaward of the 3-mile zone of the Northern New Jersey shore (Drake 1977), despite the anthropogenic influence on the particulate matter concentration from the urban area of Greater New York. In the bottom waters, the highest suspended matter concentrations varied between 2 and 5 mg/l seaward of the three-mile zone during the four sampling periods. The first three sampling events were collected during calm sea state; the final sampling event occurred during a moderate storm. The mean suspended matter concentrations in the water column during the storm were 0.5 mg/l higher than during the calm weather events, although no information was obtained from the benthic boundary layer (0 to 5 m from the seabed).

Suspended sediment levels during storms may increase by an order of magnitude or more over values during calm weather periods. However, depending on the season, these concentrations may only last for a brief period. Young (1978) observed that suspended matter concentrations in the New York Bight three days after passage of Hurricane Belle in August 1976 were similar to the concentrations observed during calm weather a year earlier.

Part of the reason could be reduced vertical mixing due to a more stratified water column in summer. Resuspension of bottom material may be more severe in winter (*e.g.*, Nelson 1977).

Information concerning the suspended sediment concentration in the bottom waters offshore of Atlantic City, New Jersey during storms is currently being investigated by Rutgers University. Initial estimates of near-bottom suspended sediment concentrations in approximately 15-meter deep water one mile from shore during a typical storm are on the order of several hundred milligrams per liter (Styles and Glenn 1999). Similar estimates of suspended sediment were made for the English Channel (Oakwood Environmental 1998). Active reworking of sediment on the shelf is also illustrated by sedimentary structures, such as sand waves, ripples and other features, on the New Jersey shelf in water depths between 30 and 143 m (McClennen 1973); the author suggested that surface sediments on the shelf might be eroded and transported as much as 30 percent of the time. The dominant forces for sediment erosion are currents and wave forces.

2.2.6.2 Dissolved Oxygen

Generally, dissolved oxygen concentrations on the Mid-Atlantic shelf are highest in the winter time, decreasing in the summer, particularly in the absence of summer storms. For example, in southern New Jersey, near-bottom dissolved oxygen concentrations ranged from 6.0 to 7.7 mg/l in a sand borrow area during measurements in October 1994 by Battelle Ocean Sciences (1995; referenced in USACE, 1996b); salinity ranged from 31.4 to 31.7 parts per thousand (ppt); temperatures ranged from 15.1 to 15.9°C.

However, in the New York Bight Apex area, low dissolved oxygen levels in bottom waters were often observed during the summers of the late 1970s and mid-1980s (*e.g.*, HydroQual 1989). In 1976, strong thermal stratification and an extensive plankton bloom resulted in hypoxic conditions (*i.e.*, dissolved oxygen concentrations of less than 2.0 mg/l) in the bottom waters of the New York Bight over a large area (NOAA 1979). One of the reasons for the low concentrations was the combination between thermal stratification and nutrient influx from the Hudson River and other sources in the New York area. Another reason was the dumping of sewage sludge at the 12-Mile Site. Dissolved oxygen concentrations along the northern New Jersey coast reached concentrations below 1.5 mg/l inshore of the 20 m depth interval and below 3.0 mg/l inshore of the 40 m depth interval (USEPA 1997). The dissolved oxygen concentrations improved after the disposal site was moved to the 106-Mile Site. In addition, new wastewater treatment plants in the Greater New York area reduced the nutrient loading to the Bight from land sources. Dissolved oxygen concentrations measured by the EPA between 1985 and 1994 ranged between 3 and 10 mg/l in the waters below a depth of 12 m with the exception of 102 samples (*i.e.*, 2.6% of all samples) which were below 3 mg/l. Similar dissolved oxygen concentrations were measured in 1992 in Southern New Jersey offshore from the Little Egg Inlet (Viscido *et al*. 1997). Bottom dissolved oxygen concentrations were the same in the surface and bottom waters with the exception of the summer months, particularly August when surface dissolved oxygen concentrations were approximately 7 mg/l and bottom concentrations were 3 mg/l.

2.2.6.3 Temperature

Coastal water temperature averages range from lows of approximately 2ºC in January to highs of approximately 23ºC in September or October (USACE 1996a, 1996b; Viscido *et al*. 1997). Warming of the coastal waters starts in spring. The waters may start to stratify in April and are more strongly stratified from July to September with a mixed layer depth ranging from approximately 12 to 40 feet depending on water temperatures (USACE 1996b).

2.2.6.4 Salinity

Salinities of nearshore waters are primarily affected by input of freshwater from streams and rivers, and from intrusion of continental slope water from far offshore onto the shelf. The salinity of the shelf water ranges between 30 and 35 parts per thousand (ppt). Nearshore waters that are influenced by freshwater runoff may have salinities of 27 ppt although the concentrations are strongly dependent on the volume of freshwater discharged and proximity to river mouths (*e.g.*, USEPA 1997). The freshwater discharges are highest in spring, thus reducing the salinity concentrations to their lowest levels in spring and early summer.

2.2.6.5 Nutrients

The two major nutrients essential for primary production in the ocean are phosphorus and nitrogen with other major nutrients such as silicon as well as many micronutrients and metals also necessary. Most marine systems are dominated by the availability or unavailability of phosphorus and nitrogen. The major source of phosphorous is runoff from upland sources. Nitrogen compounds also enter the sea from land runoff but a large portion also enters through the atmosphere.

The biological reactivity of nutrients, seasonal physical structure of the water column, currents and wind conditions, and remobilization from sediments affect the distribution and concentration of nutrients in the water column. The dominant factor affecting nutrients in the study area is flux associated with the major river outflows. Nutrient enrichment in offshore coastal waters cause elevated phytoplankton levels. Stoddard *et al*. (1986) indicated that enrichment could increase primary productivity by 30%. The effect of coastal outflow on chlorophyll enrichment decreases with increasing distance from shore. Enhancements are generally confined to the surface waters as the source of nutrient for phytoplankton growth are added above the seasonal pycnocline and density stratification limits exchange of nutrient rich bottom waters with surface waters. Under typical conditions, this condition limits the availability of nutrients regenerated in the sediments from reaching the surface layer, thereby limiting the impact of sediment regeneration on coastal productivity during the summer months.

2.2.6.6 Contaminants

Heavy metals and other compounds that were either introduced by humans or occur naturally in the sediments at elevated concentrations may be resuspended into the water column by the dredging process. Chemical constituents associated with sediments may be released to the water column when disturbed through dredging operations. Sediment contamination could come from erosion of material at disposal sites followed by redeposition at more distant locations. Generally, metal concentrations are associated with fine-grained sediments and sediments with elevated organic matter content. This correlation was observed, for example, in sediments in the vicinity of the New York Bight (Krom *et al*. 1985; USEPA 1997; Zdanowicz 1991). Bothner (1979) found trace metal concentrations to correlate with fine grained sediments of the Middle Atlantic continental shelf from the New York Bight to Chesapeake Bay. The locations of current dredged material disposal sites and historic dump sites are provided in Section 2.2.8.7.

2.2.7 Biological Resources

The ecology of the outer continental shelf of the Mid-Atlantic Bight, extending from Cape Cod, Massachusetts south to Cape Hatteras, North Carolina and within which the area under analysis in this environmental report lies, is unique in species composition and distribution compared to the other regions of the Atlantic Coast of the United States. Nowhere else in the Atlantic do such a wide range of cold-temperature, warm-temperature, and estuarine species exist in such variable densities and close proximity. Vertebrate populations are largely comprised of seasonally migratory species, both from the North Atlantic and the South Atlantic Bight. Invertebrate populations, both resident and transient, vary seasonally, providing vital links in the food chain for larger vertebrate organisms. These populations support large commercial fisheries and supply the United States and other nations with a substantial portion of their annual harvest from the oceans.

The abundance, biomass, and diversity of the populations inhabiting the shelf vary seasonally. While the species composition of the Mid-Atlantic Bight is seasonally dynamic, general trends can be distinguished for specific areas of the Bight based on sediment type, water depth, hydrodynamics, bathymetry, and water temperature. Most species inhabiting the continental shelf have specific distributional patterns based on these environmental parameters. The temporal and spatial heterogeneity of the shelf ecosystem should be considered when assessing the potential biological impacts of dredging operations on the outer continental shelf.

2.2.7.1 Plankton, Neuston

The plankton resources of the Mid-Atlantic Bight supply the entire ecosystem with the energy and nutrients to support the higher trophic levels of the food web. Phytoplankton and zooplankton are consumed by larval fish and invertebrates both in the water column and on the ocean floor. Productivity of planktonic populations fluctuates throughout the year as dictated by water temperature and nutrient availability.

The shallow coastal areas (within 20 km of the coast) between Cape Hatteras, North Carolina and northern New Jersey have been characterized as having the highest estimated annual phytoplankton production of the entire east coast of the United States (approximately 505 gC m^{-2} yr^{-1}) (Sherman *et al.* 1996; Gulland 1971); ranking it as one of the most productive areas in the world. In contrast, the mid-shelf area (approximately 100 – 1000 m deep) between Long Island, New York and Cape Hatteras has the lowest estimated annual phytoplankton production on the East Coast of the United States (Sherman *et al.* 1996). Phytoplankton production is dominated by single-celled diatoms, dinoflagellates, and nanoplankton (*i.e.*, coccolithophores and silicoflagellates) with diatoms having greater abundance in colder regions and nanoplankton occurring in greater abundance in warmer regions (Raymont 1963). Phytoplankton production is obviously not limited to one specific area of the continental shelf and varies at so large a scale that it is not influenced significantly by localized changes in environmental conditions.

Zooplankton populations in the Mid-Atlantic Bight are represented by approximately 400 taxa including copepods, chaetognaths, barnacle larvae, cladocerans, appendicularia, brachyuran larvae, echinoderm larvae, and thaliaceans (Sherman *et al.* 1996; Sherman *et al.* 1983). The most common zooplankton are copepods, of which *Calanus finmarchicus*, *Pseudocalanus minutus*, and *Centropages typicus* dominate in abundance and biomass. Zooplankton biomass along the coast of southern New England peaks in early spring and again, to a lesser extent, in late summer (Sherman *et al.* 1996; Sherman *et al.* 1983). For the rest of the Mid-Atlantic Bight, zooplankton biomass peaks in late summer after gradually increasing from late winter. Sherman *et al.* (1996) reported that annual zooplankton volume for the entire shelf area, as of 1988, has not changed significantly since the early 1900's, indicating that zooplankton populations in the Mid-Atlantic Bight are relatively stable.

Larval fish are also a major component of the planktonic community in continental shelf waters. Observed abundance and biomass patterns depend on species distribution, the time of year in which spawning occurs, seasonal hydrodynamics, and the degree to which individual species have been harvested by commercial and recreational fisheries. Croker (1965) observed 20 species of larval fish around the Sandy Hook peninsula of New Jersey. Of these, American eel (*Anguilla rostrata*), Atlantic herring (*Clupea harengus*), American sand lance (*Ammodytes hexapterus*), winter flounder (*Psuedopleuronectes americanus*), bay anchovy (*Anchoa mitchilli*), northern pipefish (*Syngnathus fuscus*), and Atlantic silverside (*Menidia menidia*) accounted for 98 percent of the larvae collected. In Croker's study, total abundances were highest during March and July. Ditty (1989) reported 15 different species of sciaenid larvae that could potentially occur in the water column along the outer continental shelf of the Mid-Atlantic Bight throughout the year. Species distribution was dependent on season and geographic region.

The USACE monitored larval fish populations as part of baseline data collected for future beach nourishment work off the coast of northern New Jersey from 1994 through 1996 (USACE-WES 1998). Nearshore and surfzone ichthyoplankton tows were taken (May – July) on beaches from Manasquan Inlet north to West Long Branch. Species composition was dominated by silversides (*Menidia menidia* and *M. beryllina*), anchovies, black sea bass (*Centropristis striata*), pipefish (*Syngnathus fucus*), goosefish (*Lophius americanus*), and windowpane (*Scopthalmus aquosus*). Mean densities ranged from 0.0/100 m^3 in May 1995 to 458.4/100 m^3 in June of 1996. Results were highly variable and were dependent on year-to-year recruitment sizes of individual species. The greatest densities of ichthyoplankton occurred in June 1996.

2.2.7.2 Benthos

Benthic communities of the Mid-Atlantic Bight exhibit a wide range of densities throughout the shelf and slope. Benthic communities are dominated by moderate densities of Arthropoda, Annelida, Mollusca, and Echinodermata (Figures 2-77 through 2-81) (Wigley and Theroux 1981). General geographic trends of abundance include: a decrease in abundance of arthropods and molluscs from north to south; annelids were of equal proportions in the northern and southern thirds of the Bight and were significantly greater in the central portion of the region. Observed trends in biomass for the four major taxa include: molluscs (shell weight included) accounted for almost two thirds of the biomass throughout the Bight (79 percent in the New York Bight); echinoderms were second in ranking with equal distribution throughout the Bight; annelids ranked third with the smallest individuals in the New York Bight; and arthropods were fourth in ranking with increased biomass from north to south.

Several types of benthic invertebrate communities exist on the outer continental shelf in the Mid-Atlantic Bight. These different communities include: live bottom areas, artificial reefs, and non-vegetated soft bottom communities (Gettleson 1996).

- **Live Bottom Areas**

  While not as common in the Mid-Atlantic Bight as in other coastal areas of the U.S., live bottom habitats offer structurally complex centers for fish and invertebrate production on the continental shelf. Live bottom areas are characterized by outcroppings of rocks or hard fossil substrates which are colonized by algae, sponges, hydroids, octocorals, bryozoans, and ascidians. Macroinvertebrates include crustaceans, molluscs, polychaetes, and echinoderms. These areas provide foraging and protection from predation for fish populations.

- **Artificial Reefs**

  Artificial reefs, whether created accidentally or deliberately, can occur anywhere along the continental shelf. Depending on depth and temperature a variety of benthic organisms can colonize or inhabit artificial reefs, including algae, sponges, hydroids, crustaceans, molluscs, polychaetes, and echinoderms. Once colonized by sessile and benthic organisms these structures attract fish species searching for food and refuge.

- **Non-vegetated Soft Bottom Communities**

  Non-vegetated soft bottom communities dominate the bottom habitats of the Mid-Atlantic Bight. Species composition of these areas is controlled by such factors as depth, distance from shore, sediment texture, temperature, salinity, light, and productivity of overlying water column. In the Mid-Atlantic, soft bottom communities are dominated by polychaetes (*Polygordius* sp., *Goniadella* sp., and *Lumbrinerides* sp.), bivalves (*Tellina* sp.), gastropods (*Oliva* sp. and *Terebra* sp.), and amphipods (*Pseudunciola* sp. and *Protohaustorius* sp.).

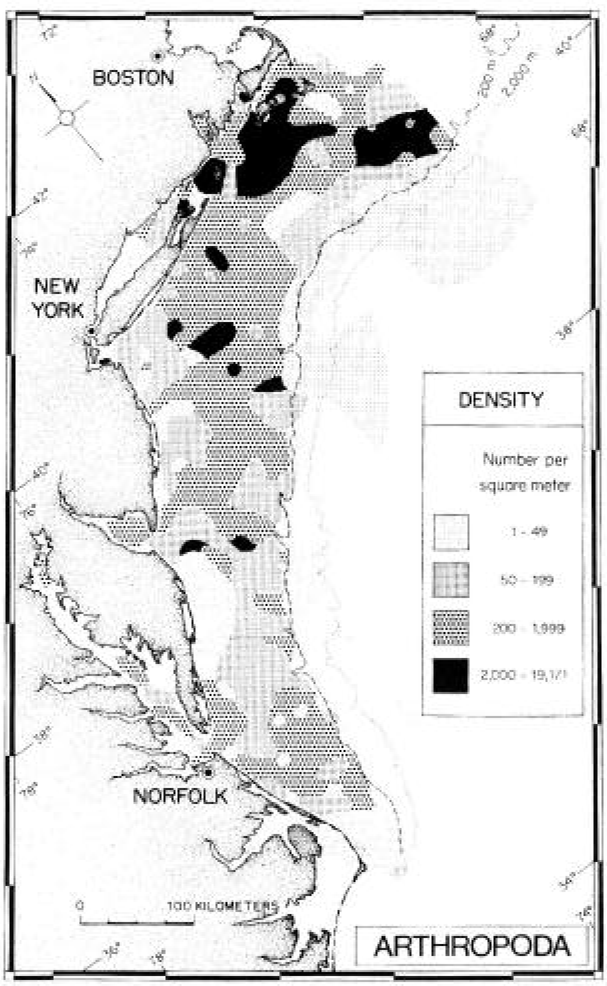


Figure 2-77. Geographic distribution of Arthropoda on Atlantic continental shelf (from Wigley and Theroux 1981).

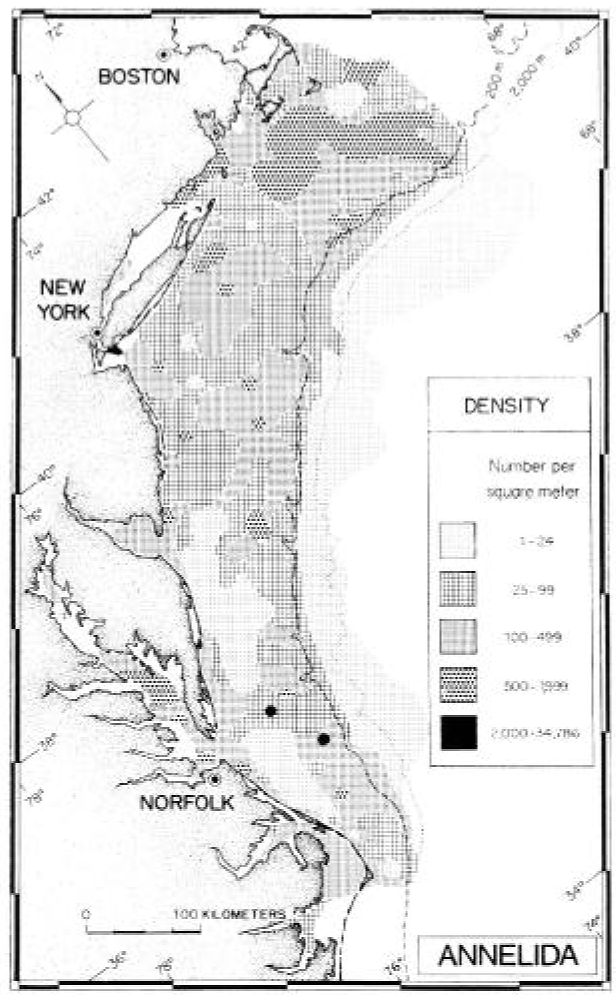


Figure 2-78. Geographic distribution of Annelida on Atlantic continental shelf (from Wigley and Theroux 1981).

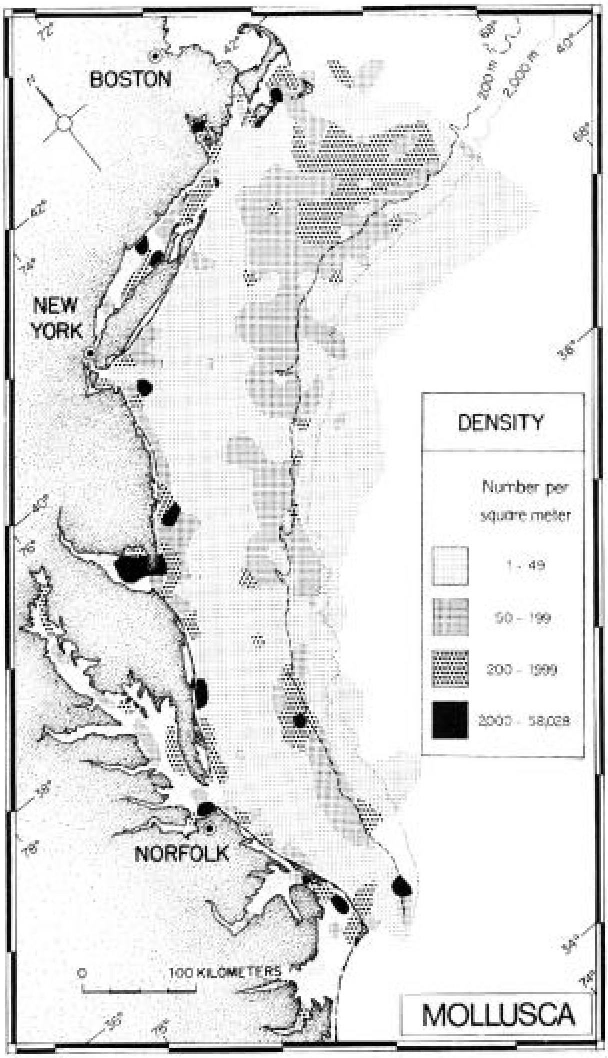


Figure 2-79. Geographic distribution of Mollusca on Atlantic continental shelf (from Wigley and Theroux 1981).

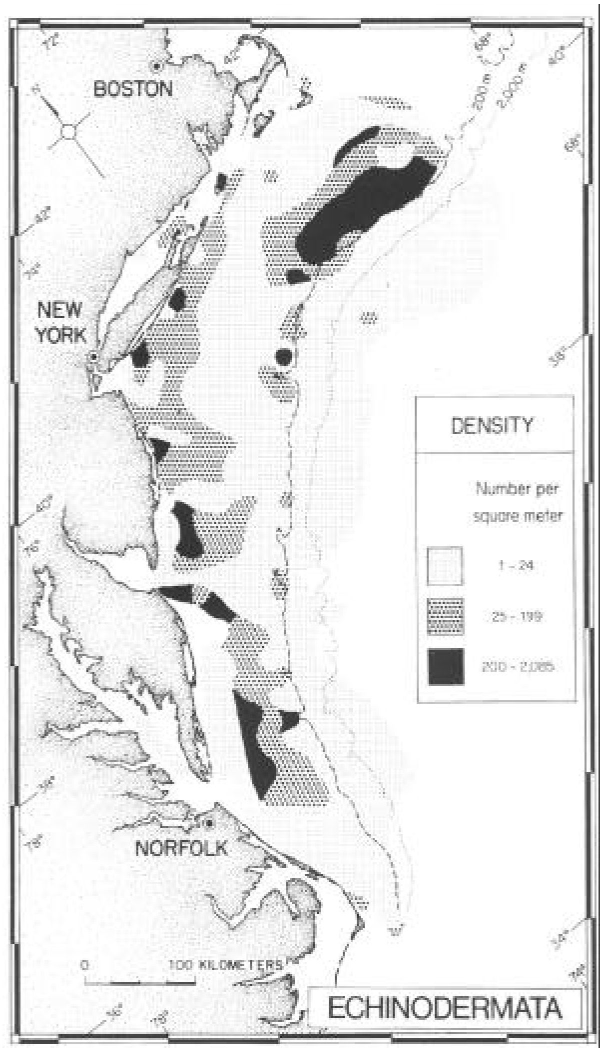


Figure 2-80. Geographic distribution of Echinodermata on Atlantic continental shelf (from Wigley and Theroux 1981).

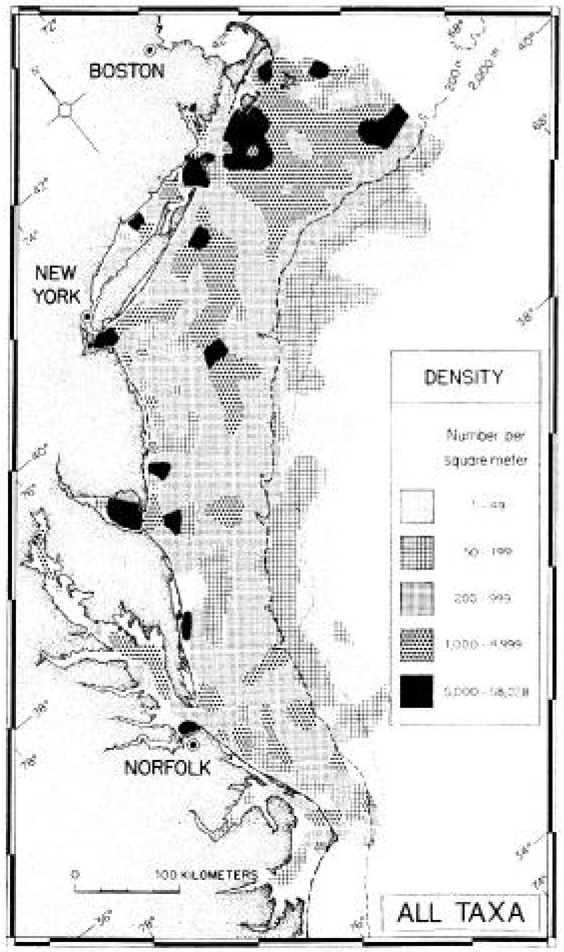


Figure 2-81. Geographic distribution of all taxa on Atlantic continental shelf (from Wigley and Theroux 1981).

Benthic invertebrates provide a critical link in the productivity of the Mid-Atlantic Bight. Benthic invertebrates, whether filtering from the water column or grazing off the substrate surface, concentrate nutrients and energy that are passed on to predators higher in the food chain (Tait and DeSanto 1972). Marine benthos are consumed by larger invertebrates, epibenthic and demersal fish species (Ulanowicz 1984), many of which support important fisheries on the Atlantic Coast. Benthic communities, as a food source for larger predators and higher trophic levels, become important when assessing the potential impacts that dredging may have on specific areas (Gulland 1970).

Benthic invertebrates can be used as indicators of environmental conditions existing in a localized area (Pianka 1970; Rees and Dare 1993). Opportunistic species generally are the first to recolonize a disturbed area. These species are able to survive a wide range of environmental conditions, tolerating the extremes in physical conditions and anthropogenic impact (McCall 1976; Holt *et al.* 1995). These organisms are generally small in size, live only in the upper few centimeters of sediment, produce large numbers of offspring, and have a relatively short live span (less than one year). In the Mid-Atlantic Bight, large populations of opportunistic species generally indicate fine grained, organic sediments. Typical opportunistic species include the polychaetes; *Streblospio benedicti, Capitella capitata* and *Owenia fusiformis,* and amphipod, *Ampelisca* spp.

Equilibrium species, however, are characterized by larger size, limited mobility, longer life span, and lower fecundity (Pianka 1970; Rees and Dare 1993). These organisms generally live deeper in the sediment and are less tolerant of disturbance and anthropogenic influences. Equilibrium species require long periods of time with little intrusion in order to survive effectively (McCall 1976; Holt *et al.* 1995). Large populations of these organisms are generally indicative of coarser grain sediment where environmental conditions have remained relatively constant for at least a few years. Typical equilibrium species in the Mid-Atlantic Bight include: *Nephtys incisa, Ensis directus, Sabellaria spinulosa, Artica islandica, Nucula* spp., *Amphiura* spp., and *Tellina* spp.

Most of the marine benthic taxa found in the Mid-Atlantic Bight have distributions ranging the entire length of the Bight or farther. Each taxa, however, has several areas of high density in specific regions of the Bight based on food sources, predation pressure, and competition with other species. Wigley and Theroux (1981) compiled over 650 benthic samples taken throughout the Mid-Atlantic Bight to describe the large-scale distributions of benthic taxa. Figure 2-81 shows the distribution of all taxa collected from their research. Based on their results it is possible to discern areas of greater density and diversity of organisms off the coast of each state.

New York/New Jersey

Several investigators have reported on studies of benthic communities on the Mid-Atlantic continental shelf. Wigley and Theroux (1981) characterized the New York Bight as having a lower density of benthic organisms compared to Southern New England and a higher density compared to the Chesapeake Bight. They observed densities of organisms between 442/m^2 and 2,430/m^2, with an overall density of 1,254/m^2 (compared to 1,544/m^2 for the entire Mid-Atlantic Bight). Distributions ranged widely from very sparse to very dense assemblages of species. The highest densities of organisms were observed in the shallowest depth class (0-24 meters). Faunal densities observed between 22 and 199 meters were half of the expected densities for that zone in the Mid-Atlantic Bight.

Boesch *et al.* (1979a) conducted a seasonal sampling program of quantitative samples from transects perpendicular to shore ranging from the Hudson Canyon in the north to Norfolk Canyon in the south, extending 30 meters to 700 meters deep. They categorized the middle Atlantic continental shelf into several macrobenthic biotopes with smaller subdivisions based on sediment composition (*e.g.*, a. muddy, b. fine sand, c. coarse sand): (1) inner shelf; (2) central shelf; (3) outer shelf; and, (4) continental slope. Numerical dominants at the outer continental shelf stations were more variable in occurrence than the inner and central shelf stations. Changes in dominant species from the inner to the outer shelf were gradual with sharp changes in the characteristic dominants existing at the shelf break.

Maurer *et al.* (1982) collected macrobenthic invertebrates from a 120-meter deep site located approximately 156 km east of Atlantic City, New Jersey. Two hundred and twenty five species of macorobenthic invertebrates were identified. Annelids, primarily polychaetes, comprised 54.2 percent of the total number of species, followed by crustaceans 19.5 percent, molluscs 16.9 percent, echinoderms 4.9 percent, and remaining taxa 4.0 percent. Densities and diversity (H') ranged from 5,155 – 11,000/m^2 and 4.34 – 5.29 respectively. Surface deposit feeding polychaetes dominated the fauna.

Chang *et al.* (1992) examined the association of benthic macrofauna with habitat types and quality from samples collected at 45 stations in the New York Bight. Analysis suggested that three species, the tube-dwelling anemone *Ceriantheopsis americanus*, polychaete *Nephtys incisa*, and nut clam *Nucula proxima* are indicators of a fine sediment habitat with high organic carbon levels. The three species also have a tolerance for high levels of trace metals. Crustaceans, including *Ampelisca agassizi* and other amphipods, as well as overall macrofaunal species density, proved to be indicators of minimally contaminated habitats.

Commercially important benthic invertebrates species which occur off of New York and New Jersey include: surfclam (*Spisula solidissima*), ocean quahog (*Arctica islandica*), Atlantic sea scallop (*Placopecten* *magellanicus*), and American lobster (*Homarus americanus*) (McHugh 1977). Various life stages of other commercially important species occur offshore including: blue crab (*Callinectes sapidus*), soft clam (*Mya arenaria*), northern quahog (*Mercenaria mercenaria*), American oyster (*Crassostrea virginica*), and bay scallop (*Argopecten irradians*). Table 2-13 provides a summary of the commercially important benthic species within the study area. More information about each species is located in its respective Fishery Management Plan (see Table 2-16).

All of these species have experienced significant population declines since the 1970's due to overharvesting and pollution. Surfclams, however, have recently recovered from previous population declines. Since 1986, 80-90% of the surfclam landings in the U.S. have come from off the New Jersey coast (Weinberg and Helser 1996); the majority from between Atlantic City and Shrewsbury Rocks (Figure 2-82) (Scott and Chailou 1997; Fay *et al.* 1983d). They are found in the shallow depth of the surf zone to depths of 60 meters offshore, usually inhabiting sandy, coarse grain substrates. Maximum concentrations occur within depths of 0 to 40 meters (NEFSC 1998c).

Surfclams prefer medium to coarse sand substrates and burrow well below the substrate surface (Fay *et al.* 1983d). Spawning is temperature dependent, occurring in mid-July to early August and again in mid-October to early November (Ropes 1980). Surfclam eggs hatch into larvae approximately nine hours after fertilization and then metamorphose from larval to juvenile stages approximately 18 days after hatching. Distribution is primarily through prevailing water currents. Juveniles and adults are capable of moving vertically through sediment or short distances across the substrate surface, but generally remain in the same location their entire lives. Adults may live 25 years, but most populations are dominated by one- and two-year-old age classes (Fay *et al.* 1983d). Surfclams tend to grow faster in northern, colder waters (Weinberg and Helser 1996) as well as deeper waters, and can reach lengths of 225 mm (Fay *et al.* 1983d). Surfclams are planktivorous, siphon feeders, consuming mostly diatoms. As with all filter feeders, increased turbidity associated with dredging activities could inhibit feeding in surfclam beds adjacent to dredging sites (Auld and Schubel 1978; Snyder 1976). Known predators include the moon snails (*Lunatia heros* and *Polinices duplicatus*), the boring snail (*Urosalpinx cinerea*), haddock (*Melanogrammus aegglefinus*), and cod (Gadidae).

The ocean quahog is a highly valued commercial commodity. It is geographically distributed on the continental shelf from Newfoundland to Cape Hatteras, occurring progressively further offshore in the southern reaches of its distribution (NEFSC 1998c). It is usually found in a sandy or sandy mud substrate, and is restricted to areas of cooler water rarely exceeding 20º C. It can survive in shallow, inshore waters when the water temperature is suitable, but prefers depth of approximately 24 – 64 meters, with highest population densities at depths between 39 – 61 m (Weissberger *et al.* 1998). They tend to burrow beneath the substrate up to a depth of one meter. Multiple spawning occurs from May to December. Larvae are planktonic before settling into benthic existence.

The sea scallop (*Placopecten magellanicus*) is generally distributed in the middle Atlantic in water depths between 40 – 200 meters with highest commercial concentrations in depths from 40 – 100 meters. Its distribution ranges from Newfoundland to North Carolina, preferring cooler waters. Spawning occurs in hard sediments from May to October, peaking in late spring. Substrate includes cobble, shell, gravel, and coarse sand.

The American lobster (*Homarus americanus*) has been harvested commercially since the 1700s and continues to be an important fishery in the northern region of the Mid-Atlantic Bight. The American lobster

Table 2-13. Commercially important benthic invertebrate species that may be encountered as eggs, larvae, or spawning adults in the Mid-Atlantic Bight (specifically offshore of New York and New Jersey).

Common Name	Species Name	Eggs	Larvae	Spawning Adults	Reference	Comments
Blue Crab	*Callinectes sapidus*	brooded by female May - Aug.	pelagic (31-79 days) offshore (up to 50 km)	nearshore - May - Oct. coastal esutaries	Hill and Fowler 1989	primarily larvae offshore
American Oyster	*Crassostrea virginica*	nearshore - pelagic	pelagic (14-21 days) settle on hard substrates	coastal estuaries	Stanley and Sellers 1986	primarily larvae offshore
Northern Quahog	*Mercenaria mercenaria*	nearshore - pelagic	pelagic (7-30 days)	nearshore - March - November prefer sand substrates	Stanley 1985	inshore pop. much larger
Ocean Quahog	*Arctica islandica*	nearshore to mid shelf	pelagic (>90 days) develop very slowly	nearshore to mid shelf summer to autumn	Clark 1998	live up to 100 years rarely found in temps < 16°
Atlantic Sea Scallop	*Placopecten magellanicus*	nearshore to mid-shelf - pelagic	pelagic (28-42 days)	nearshore to mid-shelf - late summer to early fall	Clark 1998	
Bay Scallop	*Argopecten irradians*	nearshore - pelagic	pelagic	nearshore - mid-April - early Sept. prefer sand substrates	Fay *et al.* 1983e	concentrated nearshore (within 20 km)
American Lobster	*Homarus americanus*	brooded by female (9-11 months) release peak in June - early July	pelagic 25-35 days	nearshore - prefer rocky substrates offshore - prefer mud/clay substrates	MacKenzie and Moring 1985; Clark 1998	development very temperature dependent
Surf Clam	*Spisula solidissima*	pelagic 9-72 hours	pelagic 19-35 days	nearshore to mid shelf (~75 m) mid-July - early Aug. & mid-Oct. - early Nov. prefer course sand/gravel substrates	Fay *et al.* 1983d; Clark 1998	abundances low beyond 60 m

Source: Barry A. Vittor & Associates, Inc. 1999.

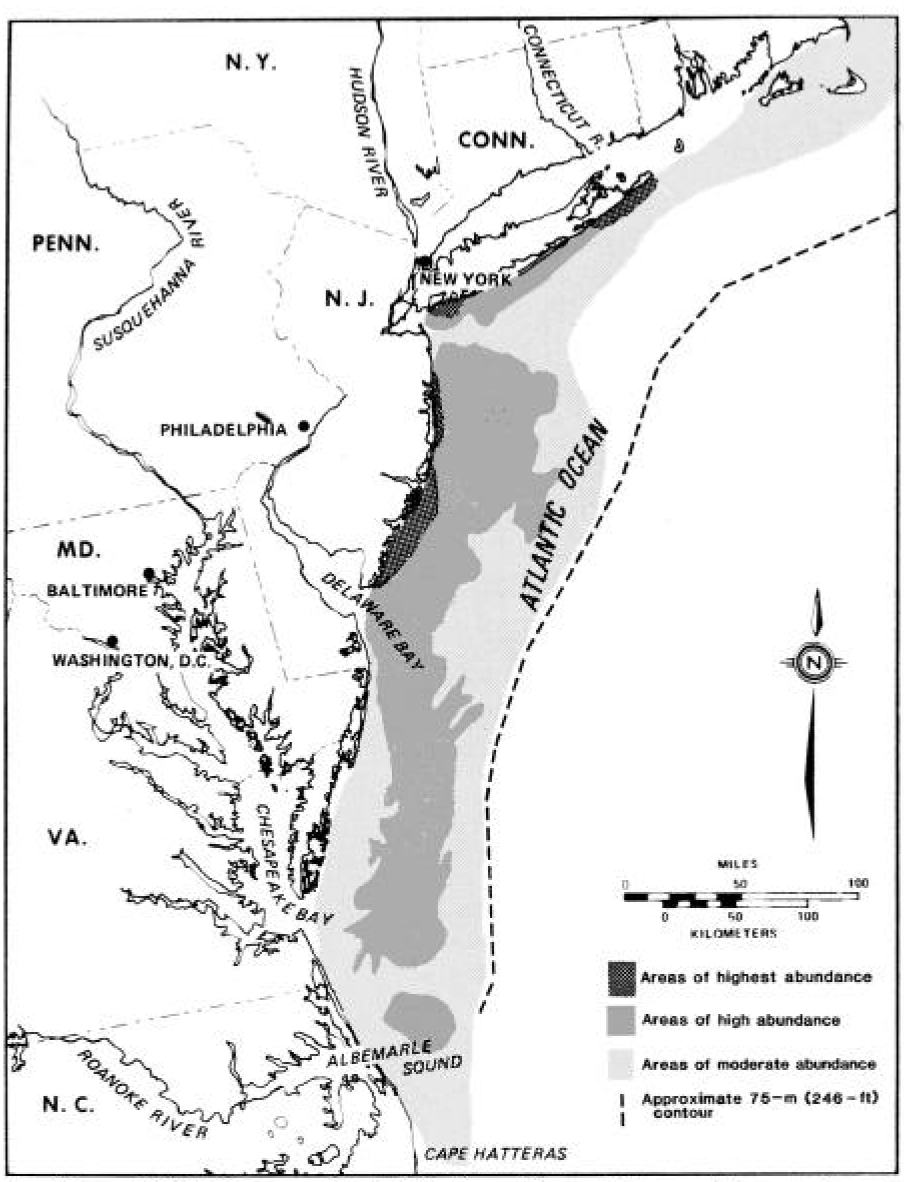


Figure 2-82. Geographic distribution of the surfclam on the Atlantic continental shelf, with relative abundances (from Fay *et al.* 1983d).

inhabits inshore and outer continental shelf waters of the Atlantic Ocean, surviving at the shallow depths of the intertidal zone and to offshore depths of 720 meters (MacKenzie and Moring 1985). Commercial concentrations in the Mid-Atlantic are usually inshore. These decapods seem to prefer sandy, hard substrate with overlying structure. American lobsters move inshore/offshore during storms, but this migration is small and the populations remain somewhat localized (Cooper *et al.* 1975). Diet consists of benthic invertebrates such as rock crabs, sea urchins, mussels, polychaetes, and sea stars.

The blue crab (*Callinectes sapidus*) is harvested primarily in the inshore brackish waters of the Mid-Atlantic states. The fishery is important and economically invaluable commercially and recreationally; concentrated primarily in the Chesapeake Bay (Hill and Fowler 1989). Spawning occurs May through October. Blue crabs move to relatively deeper waters offshore in winter, yet females may remain in the estuary for their entire life period in lieu of offshore, winter migration. Their opportunistic, omnivorous diet includes, fish, mollusks, shrimp, and other various benthic invertebrates. Diet varies with locality and availability of nutrients. The blue crab is harvested year round, but most are caught during the summer and early fall.

The horseshoe crab (*Limulus polyphemus*) utilizes both estuarine and offshore habitats, ranging from the Yucatan peninsula to northern regions of Maine. Its largest population concentration is between New Jersey and Virginia, with spawning concentrated along the Delaware Bay area. Spawning occurs from March to July as these "living fossils" begin to migrate from deeper bay waters and the continental shelf to coastal regions of Delaware Bay (Shuster and Bottom 1985). Spawning occurs on sandy beaches in low energy environments. They are commercially harvested for pharmaceutical purposes and for bait in the eel, conch, and catfish fisheries, but have ecological significance when spawning since their eggs provide a major food source for migrating shorebirds.

Two species of whelk are commercially important in the Mid-Atlantic Bight. The knobbed whelk (*Busycon carica*) and the channeled whelk (*Busycotypus canaliculatum*) are sympatrically distributed along the eastern seaboard from Cape Cod to northern Florida. They inhabit lower intertidal to subtidal waters to depths of 18 m as well as bay and ocean beach waters in salinities greater than 20 ppt. The knobbed whelk is more predominant than the channeled whelk south of Long Island, yet the channeled whelk is still harvested mutually with the knobbed whelk. Spawning transpires in the spring when the whelks migrate into coastal estuaries. Egg case laying begins in late summer to early fall with a possible second laying in the ensuing spring (Dobarro 1992). Egg cases are anchored into the substrate. Diet varies for each species, but is heavily comprised of bivalves.

Further MMS research describing the biological communities in potential sand borrow areas on the OCS off of New Jersey is currently being completed. Research sites include areas offshore of Townsend Inlet, Atlantic City, Long Beach, and Mantoloking. While not all benthic communities existing in these sites have been identified, several studies have been completed for specific locations off the coast of New York and New Jersey (Scott and Chailou 1997; Viscido *et al.* 1997).

- **Seven Mile Island** (Scott and Chailou 1997)
  Located 5.5 km east of Seven Mile Island, south of Townsend Inlet in 10 meters of water. Invertebrate samples were collected using benthic grabs. Mean faunal density was 5349/m^2 (±1152). Mean amphipod density was 40/m^2 (±28). Mean bivalve density was 327/m^2 (±119). Mean polychaete density was 3338/m^2 (±875). Mean faunal biomass was 2.55g/m^2 (±2.09). The mean number of species per sample was 21.75 (±1.69). Species diversity for the site, using the Shannon-Weiner Index (H'), was calculated to be 3.18(±0.11) species/sample. Species richness, using Simpson's Dominance Index, was calculated to be 0.81(±0.02) species/sample. Blue mussels (11.36/m^2) and surfclams (34/m^2) were present. The three most abundant polychaetes were *Aricidea cerrutti* (1011/m^2), *Polygordius* spp. (775/m^2), *Hesionura elongata* (397/m^2). The most common bivalve collected was the false angel wing, *Petricola pholadiformis* (88/m^2). Scott and Chailou (1997) characterized this site as the least desirable potential borrow area of the four areas they studied because of the relatively high density and diversity of organisms present.

- **Beach Haven Ridge** (Viscido *et al.* 1997)
  Located 4 km east of Little Egg Inlet in approximately 12 meters of water. Hales *et al.* (1995) collected invertebrate samples using epibenthic trawls. Dominant non-target epibenthos were sand shrimp (*Crangon septemspinosa*), Atlantic rock crab (*Cancer irroratus*), spider crab (*Libinia emarginata*), and lady crab (*Ovalipes ocellatus*). Nine epibenthic decapods were found at the site, with sand shrimp accounting for 98 percent of the total organisms caught. Sand shrimp abundances were highest during the fall and winter. Abundance of organisms was lower at the peak of the ridge compared to the surrounding edge. Viscido *et al.* (1997) reported a very dynamic community on the sand ridge with seasonal changes in species composition and diversity. They indicated that the ridge

was an important habitat as both a refuge from predators and as a feeding area for a wide variety of benthic and pelagic marine organisms.

Delmarva

The benthic communities on the continental shelf off the Delmarva Peninsula are very similar in species composition to the benthic communities off New Jersey. Faunal biomass and density of this region of the shelf is lower compared to the New York Bight or Southern New England (Wigley and Theroux 1981). Faunal densities on the shelf ranged from $722/m^2$ to $1742/m^2$ with an overall average of $1057/m^2$. The only area of relatively high concentrations of organisms is directly south of Chincoteague Inlet in Virginia, which is dominated by bivalves. Important benthic invertebrate species include surfclam, sea scallop, bay scallop, American lobster, blue crab, and American oyster. Commercial fisheries for surfclams off the Delmarva peninsula are second only to New Jersey in harvest potential and production (Weinberg and Helser 1996; Gusey 1976). Sea scallop populations of the Delmarva region fluctuate from year to year, but are relatively more abundant than other areas of the Mid-Atlantic Bight (Richards 1996).

- **Great Gull Bank** (USACE 1998c)
  Located 12 km east of Ocean City Inlet. Common macroinvertebrate taxa included: lobed moon snail (*Polinices duplicatus*), whelks (*Busycon* spp.), sea stars, surfclams, and horseshoe crabs (*Limulus polyphemus*).

Virginia

The characteristics of the benthic communities on the continental shelf off Virginia are very similar to the conditions observed off the Delmarva Peninsula (Wigley and Theroux 1981). Important benthic invertebrate species include surfclam, sea scallop, American lobster, and ocean quahog. Richards (1996) observed that sea scallop communities were of lower abundance and biomass compared to communities observed off the Delmarva Peninsula.

Several potential borrow areas for beach nourishment have been identified off the Virginia coast (Cutter and Diaz 1998; MMS 1998).

- **Virginia Beach** (Cutter and Diaz 1998)
  Located 2.5 km east of Virginia Beach. Benthic samples were collected with sediment profile imaging (SPI) equipment and benthic grabs. Total estimated faunal densities ranged from $1000\text{-}4000/m^2$. A total of 119 taxa were collected. Seven of the top 14 species in abundance and occurrence were polychaetes. The other seven dominant taxa were amphipods, decapods, bivalves, nemerteans, tanaids, echinoderms, and chordates. Total biomass for the study ranged between 4.1 to 7.7 g wet wt/m^2 for June and November, respectively. Annelids dominated the biomass measurements observed. The most abundant species included the polychaete *Prionospio malmgreni*, common razor clam (*Ensis directus*), keyhole sand dollar (*Mellita quinquiesperforata*), and rosey mangelonas (*Magelona rosea*). Other dominant species included *Clymenella* spp., *Asychis* spp., *Euclymene* spp., *Maldanopsis* spp., *Asabelliedes* spp., and *Dioptra* spp. The northern half of the proposed borrow area was more densely populated than the southern half. The area studied was biologically more complex than the authors had anticipated.

2.2.7.3 Fish

The Mid-Atlantic Bight represents an area of rapid transition from a cold-temperate to warm-temperate fish fauna. Over 300 species of fish occur in the Bight; most of these are seasonally migratory, with only a few species considered to be truly endemic (Sherman *et al.* 1996). Approximately 75 percent of the Bight's fish fauna is comprised of species which only venture north of Cape Hatteras during summer. Species diversity increases from north to south, with coastal and shelf areas north of Cape Cod supporting half as many species compared to waters surrounding Cape Hatteras. Many of the fish species present in the Bight migrate from nearshore to offshore seasonally, as dictated by temperature cycles, feeding opportunities and spawning periodicity (Table 2-14).

The winter fish assemblage of the Bight is dominated by species typically associated with northern waters, including cods and hakes (Gadidae), right-eye flounders (Pleuronectidae), sculpins (Cottidae), snailfishes (Clyclopteridae) and pricklebacks (Stichaidae). Migratory species include American eel (*Anguilla rostrata*), striped bass (*Morone saxatilis*) and herrings (Clupeidae). Many typically "southern" species are present in the Bight during summer, when water temperatures are high. Fishes characteristic of southern waters include drums and croakers (Sciaenidae), porgies (Sparidae), sea basses (Serranidae), grunts (Pomadasyidae), jacks and pompanos (Carangidae), and wrasses (Labridae). However, many of these families are widely distributed along the Atlantic coast, and individual species may be characteristic of northern, rather than southern waters (Moyle and Cech 1982).

Pelagic Fishes

Pelagic fishes can be found throughout the water column, swimming in variously concentrated schools. These fishes are generally streamlined, and are adapted for rapid, sustained swimming. Most pelagic species feed on smaller fish or motile invertebrates such as shrimp or squid. Many pelagic fishes, e.g. bluefish (*Pomatomus saltatrix*), are recognized as voracious predators.

Spawning and migration patterns vary among pelagic species. Large schools of American shad (*Alosa sapidissima*), alewife (*Alosa pseudoharengus*), and blueback herring (*Alosa aestivalis*) are seasonally abundant, with adults migrating to coastal waters in late spring to early summer, following spawning in freshwater reaches of major estuaries. (Fay *et al.* 1983a; Facey and Van Den Avyle 1986; Clark 1998).

American shad are anadromous, ranging from Labrador to Northern Florida. American shad migrate into coastal rivers in early spring through mid-summer, and return to coastal waters shortly thereafter, moving northwest to feeding grounds along the coast of Canada (NEFSC 1998c). American shad are planktivorous; common food items include copepods, amphipods, mysid shrimp, and occasionally small fishes. American shad migrate south along the coast during winter, returning to coastal rivers to spawn (Bigelow and Schroeder 1953).

The coastal distribution of the alewife ranges from Labrador to South Carolina; blueback herring range from Newfoundland to Northern Florida. Both species are anadromous, migrating into freshwater reaches of coastal river systems to spawn. These two species are collectively termed "river herring" and commercial and recreational fisheries for both are mixed. Alewives typically migrate further upriver than blueback herring, however, both species return to coastal waters during summer and travel north to offshore winter feeding grounds (Bigelow and Schroeder 1953). River herring are planktivorous, feeding primarily on copepods, amphipods, and shrimp.

Table 2-14. List of important recreational and commercial fish taxa that may be encountered as eggs, larvae, or spawning adults in the Mid Atlantic Bight (MAB) (specifically offshore of the Delmarva peninsula and Virginia) (Adapted from Olney *et al.* 1998).

Common name	Species name	Eggs	Larvae	Spawning Adults	Comments
Atlantic Mackerel	*Scomber scombrus*			Cape Cod - Ches. Bay	peak in May
Atlantic Herring	*Clupea harengus*		Dec-April	April to June	
Atlantic Silverside	*Menidia menidia*			Intertidal in all MAB	
Bay Anchovy	*Anchoa mitchilli*			estuaries - May-Oct	
Black Sea Bass	*Centripristis striata*		May-Nov		
Bluefish	*Pomatomus saltatrix*		Nearshore July-Aug	S. Atlantic Bight - March	larvae restricted to
Croaker	*Micropogon undulatus*		June-Aug		Mid Atlantic Bight
Menhaden	*Bryvoortia tyrannus*		Estuaries	Offshore MAB - Winter	
			Nearshore Oct-Dec		peak in Nov
			Migrate into estuaries	Nearshore Spring & Fall	
			Oct-June		
Red Hake	*Urophycis chuss*		Offshore Aug-Nov		
Scup	*Stenotomus chrysops*		May-July		
Silver Hake	*Merluccius bilinearis*			Nantucket Shoals to VA	peak in June
				June to Dec	
			Nearshore April-May		
			Offshore April-June		
Striped Anchovy	*Anchoa hespetus*		Sept-Nov		
Striped Bass	*Morone saxatilis*			Delaware-Ches.Canal - April-June	spawn in fresh
Spot	*Leiostomus xanthurus*	Continental Shelf	Migrate into estuaries	Inshore/Offshore Oct-March	water estuaries
		winter	Dec-April		Mid-Atlantic coast
Summer Flounder	*Paralichthys dentatus*			Block Is.-Cape Hatteras - Sept-Oct	peak in Oct
				Estuarine & coastal MAB - Sept-Feb	
		Continental shelf N. of	Continental shelf N. of	Continental shelf N. of Ches Bay	
		Ches. Bay - Sept - Nov	Ches. Bay - Sept - Feb	Nov - Feb	
		Nearshore - continental	Nearshore to continental		
		shelf Sept - Dec	shelf Oct-Dec		
		Pelagic	Migrate to estuaries	Offshore - continental shelf	
				Sept - March	
Weakfish	*Cynoscion regalis*		Nearshore-Offshore	Nearshore & estuarine - May-July	
Winter Flounder	*Psuedopleuronectes americanus*	Demersal - estuaries	Bays & Estuaries	Bays & estuaries	
				Nov-June	
Windowpane	*Scopthalmus aquosus*			Block Is. - Cape Hatteras- April-Dec	peak in Oct
Yellowtail Flounder	*Limanda ferruginea*			S. of Martha's Vineyard - April-Aug	peak in May-June

Atlantic herring are widely distributed in open waters of the Bight. Unlike American shad and river herring, Atlantic herring are oceanic spawners. Atlantic herring prey selectively on zooplankton, primarily copepods and other small crustaceans. Adults migrate extensively from feeding grounds in northern waters to the Mid-Atlantic region during winter (Clark 1998). Atlantic herring represent a significant prey resource for larger, predatory fishes and marine mammals.

Bluefish are widely distributed in the northern and southern hemispheres, and occur from the Gulf of Maine to the Florida Keys along the U.S. Atlantic coast. Bluefish are harvested both commercially and recreationally in the Mid-Atlantic Bight, and are an important pelagic predator, feeding on a wide variety of demersal and pelagic fish species. Bluefish migrate along the shelf throughout the year, reaching peak abundance in the Bight during summer (Pottern *et al.* 1989). Larvae spawned in open waters south of the Bight are transported northward and spend their first summer in Mid-Atlantic estuaries. Larvae spawned from June-August in the Mid-Atlantic Bight visit estuaries only briefly, if at all, and juveniles migrate south in late fall (Kendall and Walford 1979; Nyman and Conover 1988; Chiarella and Conover 1990).

Striped bass are indigenous to the North American Atlantic coast, ranging from the St. Lawrence River in Canada to the St. Johns River in northern Florida, but have been widely introduced elsewhere, including the U.S. Pacific coast and the Gulf of Mexico, as well as numerous inland waters. Striped bass are anadromous, spawning in fresh or brackish estuarine waters in spring. Juveniles migrate to coastal waters during summer and fall. Principal spawning areas for striped bass in the Mid-Atlantic region are located in the upper Chesapeake Bay and its major tributaries. The Hudson River, Delaware Bay, and Albemarle-Pamlico Sound, are also recognized as significant or potentially significant striped bass spawning areas (Fay *et al.* 1983b; Boreman and Austin 1985; Richards and Deuel 1987). Adult striped bass are widely distributed along the Mid-Atlantic continental shelf. However, a substantial portion of the Atlantic coastal striped bass stock does not migrate far from their estuaries of origin (Kohlenstein 1981; Waldman *et al.* 1990). Striped bass prey upon a variety of fishes and crustaceans, including Atlantic menhaden, river herring, and blue crabs.

White perch (*Morone americana*) are closely related to striped bass, and are abundant in estuaries and coastal bays along the Atlantic coast, from Nova Scotia to South Carolina. White perch are harvested commercially and recreationally throughout the Mid-Atlantic Bight. Spawning takes place in the upper reaches of tidal rivers during spring, and the young-of-the-year take up residence in tidal creeks and shallows. White perch are considered semi-anadromous, as they do not undertake the extensive coastal migrations characteristic of striped bass, and generally remain in the estuary proper (Mansueti 1961, 1964; Holsapple and Foster 1975). White perch prey upon a variety of invertebrates and small fishes. They, in turn, are often consumed by larger predatory fishes.

American eels are an example of a catadromous species, with adults spawning in the Sargasso Sea, and large numbers of larvae (or leptocephali) metamorphosing into juveniles (elvers) before migrating into estuaries, streams and rivers along the Atlantic coast (Smith 1968; Ogden 1970; Wenner and Musick 1975). Its geographical distribution ranges from Greenland to northern South America (Robins *et al.* 1986) with population concentration in the North Atlantic. Eels remain in freshwaters for up to 12 years before migrating seaward to spawn. Spawning migration occurs in the autumn when mature eels begin metamorphosis into the silver eel stage (Kleckner *et al.* 1983). They migrate seaward, spawn, and die. Larvae or leptocephali are transported inshore by current and elvers migrate upriver and into fresh water systems in late winter and early spring. American eels are primarily bottom-feeders, consuming a variety of benthic invertebrates, amphibians (in freshwaters), and small fish. American eels are preyed upon by a variey of larger predatory species, including bluefish and striped bass. American eels represent an important fishery resource in the Mid-Atlantic Bight, with much of the commercial harvest shipped overseas to Europe and Asia (Van den Avyle 1984).

Weakfish (*Cynoscion regalis*) and spotted seatrout (*Cynoscion nebulosus*) are important predators in nearshore and shelf areas of the Mid-Atlantic Bight. Weakfish are generally encountered inshore from Cape Hatteras to Newfoundland and are common throughout the Bight. Spotted seatrout range from New York to Mexico and are more prevalent in the southern reaches of the Bight. Both species are considered commercially and recreationally important throughout their range. Weakfish are considered a seasonal component of the fish assemblage in the northern portion of its range, and considered an estuarine resident species in the Carolinas. Weakfish migrate from offshore waters of Virginia and North Carolina in spring, spawn inshore from May to October, and migrate inshore to lay eggs (Merriner 1976). Weakfish and spotted seatrout have overlapping spawning areas in waters where they co-occur. However, spotted seatrout tend to spawn in shallow bays and estuaries, while weakfish prefer to spawn in the deeper waters of channels and passes. Weakfish and spotted seatrout return to wintering areas offshore in late fall (Shepherd and Grimes 1983; 1984; Lassuy 1983; Mercer 1989a). The diets of weakfish and spotted seatrout are variable, depending on location (inshore vs. deeper coastal waters), and may include a variety of small fish (anchovies, killifish, herring, menhaden) and crustaceans (blue crabs, penaeid and caridean shrimp).

Other sciaenids of importance in the Mid-Atlantic Bight include Atlantic croaker, spot, kingfish (*Menticirrhus* spp.), red drum (*Sciaenops occellatus*), and black drum (*Pogonias cromis*). The life history of sciaenids is closely linked to estuarine nursery areas; all of the Sciaenidae utilize estuarine habitats to some degree, as juveniles, adults, or both (Joseph 1972).

Red drum range along the Atlantic coast from Florida to Massachusetts, and along the Gulf Coast to Mexico. This species supports important commercial and recreational fisheries, especially in the southern portion of the Mid-Atlantic Bight (Virginia and the Carolinas). Red drum spawn offshore in late summer and fall. Juveniles rely on shallow bays and estuaries as a nursery and forage area. Red drum are significant predators in southern estuaries, feeding upon a variety of crustaceans (penaeid shrimp, blue crabs) and forage fishes (Reagan 1985).

Black drum range from Nova Scotia to Argentina, and are the largest of the sciaenids occurring in the Mid-Atlantic Bight. Black drum spawn offshore in spring and summer, and juveniles rely on estuaries as a nursery and forage area (Richards 1973). Black drum prey mostly upon molluscs and crustaceans, especially penaeid shrimp and blue crabs.

Spot and Atlantic croaker are smaller members of the Sciaenidae, and are harvested commercially and recreationally throughout the Mid-Atlantic Bight. Both species range from the Gulf of Maine to Argentina. Spot and Atlantic croaker are characterized by an extended offshore spawning season in the Bight, ranging from September to April. Post-larvae begin to appear in estuaries in early spring, and juveniles remain inshore throughout the summer (Chao and Musick 1977; White and Chittenden 1977). Spot and croaker are opportunistic bottom feeders; juvenile spot are known to prey heavily on meiofauna in shallow marsh habitats, especially harpacticoid copepods (Ellis and Coull 1989; Feller *et al.* 1990). Larger individuals prey upon a variety of smaller crustaceans and polychaetes.

Kingfish, or “whiting” are widely distributed in the surf zone and in shallow inshore waters in the Mid-Atlantic Bight. Three species are typically encountered in the Bight, and fishermen rarely distinguish among them. The Northern kingfish (*M. saxatilis*) ranges from Maine to Florida and is most common north of Virginia. The southern kingfish (*M. americanus*) ranges from New York to Texas, and is most common south of Cape Hatteras. Gulf kingfish (*M. littoralis*) range from the Chesapeake Bay to Mexico. Kingfish spawn offshore in spring and early summer (Bigelow and Schroeder 1953; Hildebrand and Cable 1934). Common prey items include polychaetes, a variety of crustaceans, (especially penaeid shrimp and blue crabs), and occasionally small fish.

Common forage species in the Mid-Atlantic Bight include the various killifishes (*Fundulus* spp.), silversides (*Menidia* spp.), anchovies (*Anchoa* spp.), mullets (*Mugil* spp.), and Atlantic menhaden (*Brevoortia tyrannus*). Mummichogs (*Fundulus heteroclitus*) and striped killifish (*F. majalis*) are resident species which are abundant throughout the year in the tidal marshes and shallow waters of estuaries and coastal bays from the Gulf of St.

Lawrence to northern Florida (Abraham 1985). Bay anchovies (*Anchoa mitchelli*) are abundant and widely distributed in mid-Atlantic estuaries and coastal bays, and are an important prey resource for predatory fishes and sea birds (Morton 1989). Atlantic silversides (*M. menidia*) are often the most abundant fish species present in nearshore waters of the Bight during summer, and overwinter in deeper, offshore waters (Conover and Murawski 1982; Fay *et al.* 1983c).

The Atlantic menhaden is a filter-feeding, schooling fish and is considered one of the most important commercial fishery resources along the U.S. Atlantic Coast. Vast schools of Atlantic menhaden undertake extensive north-south and inshore-offshore migrations in the Bight. Atlantic menhaden spawn year-round, with distinct peaks in spring and fall (Nelson *et al.* 1977). The most extensive spawning activity occurs just south of the Bight, approximately 20-30 miles offshore, from December through February. Adults move inshore and northwest during spring, with distribution stratified by age and size class. The schools return south during the fall. A winter spawn occurs in deeper, offshore waters. Atlantic menhaden are selective particle feeders, prior to undergoing metamorphosis to the juvenile stage. Juvenile and adult Atlantic menhaden are planktivorous, and consume a variety of zooplankton and phytoplankton. Atlantic menhaden are an important prey item for many pelagic predators, including bluefish and striped bass (Rogers and Van Den Avyle 1983).

Both striped mullet (*M. cephalus*) and white mullet (*M. curema*) are common in the southern reaches of the Mid-Atlantic Bight, especially in estuaries and shallow inshore waters. In the northern reaches of the Bight, mullet are only present seasonally, mostly in late summer/early fall. In the southern portion of the Bight, striped mullet are present year around, while white mullet are present from spring to late fall. Mullet are primarily detritus feeders, and generally do not consume large prey organisms. Mullet, like menhaden, constitute an important forage resource for a variety of predatory species.

Jacks and pompanos, typically associated with southern and sub-tropical waters, are seasonally abundant in the lower reaches of the Bight. Commonly encountered species include lookdown (*Selene volmer*), crevalle jack (*Caranx hippos*), blue runner (*Caranx crysos*) and Florida pompano (*Trachinotus carolinus*).

Butterfish (*Peprilus triacanthus*) and harvestfish (*Peprilus alepidotus*) are common in deeper waters of the Bight during fall and winter. Butterfish range from Florida to Newfoundland, but are most abundant north of Cape Hatteras, traveling in loosely organized schools (Bigelow and Schroeder 1953). Butterfish and harvestfish move inshore, and northwest, during summer to feed and spawn. They return offshore, and to the south, in late fall, seeking warmer water. Butterfish feed primarily on small fish and crustaceans. Butterfish are commercially harvested in the Bight, and are consumed by a variety of pelagic predators, including hakes, bluefish and squid (Murawski and Waring 1979).

Tunas and mackerals (Scombridae) are fast swimming oceanic wanderers, and several species are common throughout the Bight. Representative species include albacore (*Thunnus alalunga*), little tunny (*Euthynnus alletteratus*), yellowfin tuna (*Thunnus albacares*), blackfin tuna (*Thunnus atlanticus*), and bigeye tuna (*Thunnus obesus*). Atlantic mackerel (*Scomber scombrus*) spawn in the Bight from April to June and undertake extensive northern and southern migrations during spring and fall, respectively (Clark 1998). Atlantic bluefin tuna (*Thunnus thynnus*) are the largest members of the Scombridae, and are a highly sought after game and food fish in the Bight and elsewhere. Atlantic bluefin tuna undertake extensive oceanic spawning migrations, including occasional trans-oceanic crossings. The western Atlantic population spawns primarily in the Gulf of Mexico during late spring (Sissenwine *et al.* 1998).

In addition to pelagic fishes, several species of squid (Cephalopoda) are important constituents of the open water nekton community of the Bight. Two species are harvested commercially, the northern shortfin squid (*Illex illecebrosus*) and the longfin inshore squid (*Loligo pealeii*). The northern shortfin squid is highly migratory and widely distributed in outer continental shelf and slope waters. Spawning occurs south of Cape Hatteras during winter. Larvae and juveniles are transported north in Gulf Stream waters, and young-of-the-year migrate inshore in late spring (Lange and Sissenwine 1980; Clark 1998). Longfin inshore squid also migrate seasonally, spawning inshore and moving offshore to overwinter at the edge of the continental shelf (Brodziak and Macy 1996; Clark 1998).

Demersal Fishes

Many fish species are adapted to life on the ocean bottom. These species tend to be solitary, rather than schooling, and prey upon benthic infauna and epifauna. Many epibenthic fishes, such as flounders, are capable of burrowing into soft substrates, and prey upon small fishes or motile invertebrates in the lower portion of the water column. Examples of benthic or epibenthic fishes commonly encountered in the Mid-Atlantic Bight include the cods and hakes (Gadidae), kingfishes (Sciaenidae), sturgeons (Acipenseridae), eelpouts (Zoarcidae), puffers (Tetraodontidae), sculpins (Cottidae), searobins (Triglidae), and goosefish (*Lophius americanus*). Flounders, including summer flounder (*Paralichthys dentatus*), winter flounder (*Pseudopleuronectes americanus*), witch flounder (*Glyptocephalus cynoglossus*), yellowtail flounder (*Limanda ferruginea*), and windowpane flounder (*Scopthalmus aquosus*) are bottom-oriented predators which feed on small fish and crustaceans.

The winter flounder is most abundant from the Gulf of St. Lawrence to the Chesapeake Bay. It is a common species in shallow bays and estuaries, and occurs offshore to depths of approximately 32 meters (Briggs 1978). Winter flounder migrate seasonally, as determined by spawning periodicity and temperature. Inshore spawning migrations begin in November, and most individuals move offshore by June. Winter flounder lay large demersal eggs which are attached in clumps to the seafloor. Spawning activity peaks between February and March in the Mid-Atlantic region, but varies with latitude, occurring earlier in southern reaches of the Bight, and progressing north. Most juveniles move offshore with adults during spring and summer (Grimes *et al.* 1989; Clark 1998). Restricted migration in coastal waters, and observed differences in meristic and morphometric characteristics suggest the existence of distinct sub-populations among estuaries of the Bight (Brown and Gabriel 1999). Winter flounder feed on a variety of benthic prey, including small fish, polychaetes, crustaceans, and mollusks. Winter flounder are primarily sit-and-wait predators, and prefer sandy, rather than muddy substrates, where they can camouflage themselves and effectively prey upon motile organisms.

Summer flounder, or fluke, are considered an important commercial and recreational resource throughout the mid-Atlantic Bight. Summer flounder spawn along the outer continental shelf during fall and larvae are widely distributed in shelf waters throughout winter and spring. Larvae are transported inshore by water currents and juveniles enter shallow bays and estuaries of the Bight. The major nursery areas for summer flounder are located from Virginia southward, although the estuaries of southern New Jersey, especially Great Bay and Little Egg Harbor, are also recognized as important summer flounder nurseries (Szedlmayer *et al.* 1992). Juveniles leave estuarine nurseries in fall, migrate offshsore to overwinter, and return to estuaries in spring, along with adults (Able *et al.* 1989; Grimes *et al.* 1989). Summer flounder prefer sandy substrates; however, they may commonly occur in association with manmade structures (e.g. docks, piers, and pile fields) and among eelgrass (*Zostera marina*) beds. Summer flounder are primarily sit-and-wait-predators, and can effectively camouflage themselves. Common prey items include small fish and crustaceans, polychaetes, molluscs (including squid) and echinoderms.

Yellowtail flounder and witch flounder are relatively sedentary, preferring deeper offshore waters. Limited seasonal inshore migration of yellowtail flounder has been documented in the Bight (Clark 1998). Windowpane flounder are widely distributed throughout the Bight, inhabiting both inshore and offshore shelf environments (Morse and Able 1995; Clark 1998).

Silver hake (*Merluccius bilinearis*) are important predators, feeding on a variety of fish and invertebrates, including herring, butterfish, mackerel, menhaden, shrimp, and squid. This species is harvested commercially in the northern reaches of the Mid-Atlantic Bight. Silver hake are highly migratory, moving inshore during spring to spawn and returning to deeper shelf and slope waters during fall (Helser 1996; Clark 1998; NEFSC 1998c).

Two distinct stocks are recognized along the Atlantic coast. The northern stock ranges from Newfoundland to George's Bank, and the southern stock ranges from south of George's Bank to South Carolina. Silver hake can be found at a wide range of depths, from shallow bays and estuaries to continental shelf and slope waters as deep as 183 meters.

Red hake (*Urophycis chus*) are common in the northern reaches of the Mid-Atlantic Bight, and also undergo a seasonal migration. This species ranges from southern Labrador to North Carolina, reaching peak abundance off the coast of New Jersey. Red hake can be found at a wide range of depths, from shallow inshore waters down to 230 meters (Robins *et al.* 1986). Red hake spawn from May through November in the northern reaches of the Bight and overwinter along the outer continental shelf and slope (Clark 1998). Most juveniles move inshore after settling; however some juveniles remain in deeper waters, where they may seek refuge in shells of the giant scallop. Important prey items for red hake include shrimp and other crustaceans, and small demersal fish, especially sand lance (*Ammodytes* spp.).

Sand lances are small, elongate burrowing fishes, two species of which are known to occur in the Mid-Atlantic Bight. The American sand lance (*A. hexapterus*) ranges from Quebec to North Carolina while the northern sand lance (*A. dubius*) ranges from Labrador to Virginia. Sand lances are abundant in sandy habitats both inshore and offshore, feed primarily on zooplankton, and are an important food resource for many predatory species (Auster and Stewart 1986). A minor baitfishery exists for this species in New England and the Mid-Atlantic region.

The Atlantic sturgeon (*Acipenser oxyrhynchus*) and the shortnose sturgeon (*A. brevirostrum*) are primitive bony fishes which have historically supported significant fisheries in the Mid-Atlantic Bight, and were an important natural resource for native american populations along much of the U.S. east coast (Smith *et al.* 1984). Currently the Atlantic sturgeon is protected throughout much of its range which extends from Labrador to the Gulf of Mexico. The shortnose sturgeon is federally listed in the U.S. as an endangered species, and ranges from Nova Scotia to Florida (Gilbert 1989). Both species are anadromous, with the shortnose sturgeon exhibiting a marked preference for freshwater habitats. Landlocked populations of shortnose sturgeon have been established along the U.S. east coast by damming of coastal rivers. Both species spawn in fresh water, as early as February and extending into early July, depending on latitude. The shortnose sturgeon's spawning season generally precedes that of the Atlantic sturgeon at comparable latitudes. Following spawning, spent adults move downriver, and enter coastal waters. Adults migrate upstream again in late fall to overwinter in deep river channels. Sturgeon are well-adapted for feeding in soft sediments, using their barbels, and "vacuuming" the substrate with their protruding mouths. Principal prey items include molluscs, polychaetes, crustaceans, and small demersal fishes, such as sand lance.

Tilefish (*Lophalotilus chamaelonticeps*) are a large, deepwater species which occupy horizontal burrows in submarine canyon walls and scour depressions around boulders. The burrowing activity of tilefish is known to enhance local abundance and diversity of small fish and crustaceans, and may play a role in structuring outer continental shelf infaunal communities (Turner *et al.* 1983; Grimes *et al.* 1988).

Ocean pouts (*Macrozoarces americanus*) are benthic, eel-like fish common in the northern reaches of the Bight. Like many demersal species, ocean pouts do not undergo extensive seasonal migrations; rather, they move locally to different substrates. During winter and spring, ocean pouts feed on benthic invertebrates inhabiting sand and gravel bottoms. In summer, ocean pouts cease feeding and move to rocky areas to spawn (Clark 1998).

Reef-Dwelling Fishes

Many bottom-oriented species are associated with reefs, rock piles or wrecks in waters of the Mid-Atlantic Bight. Sheepshead (*Archosargus probatocephalus*), scup (*Stenotomus chrysops*), black sea bass (*Centropristis* *striata*), tautog (*Tautoga onitis*), cunner (*Tautogolabrus adspersus*), filefishes (Balistidae), grunts (Haemulidae), and cobia (*Rachycentron canadum*) are common among reefs or wrecks. Many reef-dwelling fish have small mouths with strong teeth, adapted for removing fouling organisms from hard surfaces and crushing shells. Common prey items for reef-dwelling species include mussels, barnacles, clams, amphipods, shrimp, and juvenile American lobsters.

Tautog and cunner are highly dependent upon cover and shelter provided by reefs. Like other wrasses, they are active by day and quiescent at night. During the quiescent period they must remain alongside or underneath an object. Shelter site availability may limit the population size of tautogs and cunners throughout the Bight. Both interspecific and intraspecific competition for shelter sites is also a potential limiting factor. Many reef-dwelling species have limited home ranges, usually less than several hundred meters from shelter sites. However, the proliferation of artificial reefs along the Atlantic coast in recent years may be providing for expansion of tautog and cunner habitat into open, sandy-bottom areas. Tautog and cunner spawn in shallow inshore waters from May-August, migrating offshore to overwinter in fall. They generally remain inactive in shelter sites during winter, and do not feed at this time (Auster 1989). Mark and recapture studies have indicated that tautog return to the same spawning locations in successive years. Tautog are harvested commercially in the Mid-Atlantic Bight; most fisheries are concentrated at approximately the 5 meter depth contour, as this species is most abundant between 5 – 10 meters.

Scup, or porgy, range from Nova Scotia to Florida, and are most abundant north of the Carolinas (Robins *et al.* 1986). Scup are commercially harvested in the Mid-Atlantic Bight, where they are concentrated among artificial and natural structures, at depths from < 5 to >35 meters. Scup migrate inshore and northwest to spawn between April and October, moving offshore to deeper continental shelf and slope waters in late fall (Bigelow and Schroeder 1953). Scup feed primarily upon benthic and epibenthic crustaceans, polychaetes and juvenile fish.

Sheepshead range from southern New England to Texas, and are closely associated with artificial reefs, jetties, pilings, and other nearshore and offshore structures. Their strong, crushing jaws and teeth, are specifically adapted for feeding upon epifaunal invertebrates (*e.g.*, barnacles and molluscs) which encrust submerged hard surfaces. Sheepshead spawn offshore during spring, and postlarve and juveniles move into shallow inshore nursery areas (Jennings 1985).

Black sea bass inhabit artificial reefs, rubble mounds, and shipwrecks along the entire Atlantic coast. Two distinct stocks are recognized, one occurring south of Cape Hatteras and another to the north. Black sea bass are migratory in the Mid-Atlantic region, moving inshore (to within 10 m) and north in spring; and offshore (to approximately 35 meters) and south during fall. Spawning begins in early spring in the southern reaches of the mid-Atlantic Bight and occurs progressively later throughout spring and summer farther north. Black sea bass are among the most abundant species associated with artificial reefs in the Mid-Atlantic Bight and elsewhere along the U.S. east coast (Mercer 1989b), feeding extensively on epifaunal

invertebrate communities (*i.e.*, echinoderms, molluscs, crustaceans) associated with hard structures (Musick and Mercer 1977).

Sharks, Skates, and Rays

A variety of elasmobranch species are common in the waters of the Mid-Atlantic Bight. The highly saline coastal bays along the Delmarva Peninsula support a large number of species; small commercial and sport fisheries for sharks have historically persisted in this region (Hoese 1962). Requiem sharks (Carcharinidae) are common inshore and offshore; representative species include sandbar shark (*Carcharinus plumbeus*), bull shark (*C. leucas*), blacktip shark (*C. limbatus*), and dusky shark (*C. obscurus*). Sandbar sharks range from Massachusetts to the Gulf of Mexico, and are one of the most abundant sharks in shallow bays and estuaries in the Mid-Atlantic region from spring to late fall (Medved and Marshall 1983). During fall, juveniles and young adults move offshore and south to wintering grounds between North Carolina and southern Florida. Adults greater than five years of age cease to migrate inshore, instead they remain offshore and undertake lengthier north-south migrations. Inshore movements of sandbar sharks are strongly influenced by tidal currents; and to a lesser extent, by the movements of schools of forage species (*e.g.*, Atlantic menhaden).

Hammerhead sharks (*Sphyrna* spp.) are common both inshore and offshore. Smooth dogfish (*Mustelus canis*) and spiny dogfish (*Squalis acanthius*) are common throughout the Bight, travelling in large schools and preying upon a variety of fishes and macrocrustaceans (Clark 1998). Smooth dogfish are seasonally abundant in Mid-Atlantic estuaries; adults are present from April to September and young-of-the-year are present from May through October (Rountree and Able 1996).

Clearnose skates (*Raja eglanteria*), little skates (*Raja erinacea*), and barndoor skates (*Raja laevis*) are common throughout the Bight, from inshore to deeper waters. The rosette skate (*Raja garmanni*) is a deepwater species, common in waters along the outer continental shelf and slope. Atlantic stingray (*Dasyatis sabina*), southern stingray (*D. centroura*), bluntnose stingray (*D. sayi*) and cownose ray (*Rhinoptera bonasus*) are common in nearshore waters of the Bight, especially in the southern reaches.

Skates and rays forage exclusively on benthic invertebrates, especially bivalves. Large schools of cownose rays undergo extensive feeding migrations in coastal waters, and their feeding activities may have significant effects on soft bottom microtopography and infaunal community structure. Many elasmobranch species, especially dogfish and skates, are opportunistic, and often experience significant population increases in response to a decrease in populations of commercially exploited finfish species (Sherman *et al.*, 1996).

2.2.7.4 Essential Fish Habitat

The Magnuson-Stevens Fishery Conservation and Management Act, as amended by the Sustainable Fisheries Act of 1996 (PL 104-267), established the requirement to describe and identify essential fish habitat (EFH) within each fishery management plan (FMP) using text and maps. An EFH is defined as those waters and substrate necessary to fish for spawning, breeding, feeding, or growth to maturity (Magnuson-Stevens Act, 16 U.S.C. 1801 et seq). “Waters” include all aquatic areas and their associated physical, chemical, and biological properties that are utilized by fish or historically used by fish when appropriate. “Substrate” includes sediment, hard bottom, underwater structure, and all associated biological communities. “Necessary” is defined as the habitat required to support a sustainable fishery and the managed species’ contribution to a healthy ecosystem. “Spawning, breeding, feeding, or growth to maturity” covers a species’ entire life cycle and all habitat types necessary for these processes (EFH Interim Final Rule, 62 FR 66531). Current FMP's for Mid-Atlantic Fishery Management Council (MAFMC), South Atlantic Fishery Management Council (SAMFC), and New England Fishery Management Council (NEFMC) designate EFH for federally regulated species within the Mid-Atlantic Bight. The Sustainable Fisheries Act of 1996 (SFA) requires the fishery councils (NEFMC, MAFMC, and the SAFMC for the Atlantic coast) to identify these EFHs to better manage and conserve each species.

Specific descriptions and identifications for EFHs have been defined in appropriate amendments to various FMP’s. The Mid-Atlantic Fishery Council’s Amendment 12 to the Atlantic Surfclam and Ocean Quahog Fishery Management Plan identifies the following parameters for the essential fish habitat of these two pelecypods by their juvenile and adult life stages. These benthic habitats are specifically defined as the following:

Surfclam: Throughout the substrate, to a depth of three feet below the water/sediment interface, within federal waters from the eastern edge of Georges Bank and the Gulf of Maine throughout the Atlantic EEZ, in areas that encompass the top 90% of all the ranked ten-minute squares for the area where surfclams were caught in the NEFSC surfclam and ocean quahog dredge surveys. Surfclams generally occur from the beach zone to a depth of about 200 feet, but beyond about 125 feet abundance is low (Amendment 12 to the Surfclam and Ocean Quahog FMP, 1998). The Atlantic surfclam EFH designation maps are provided in Appendix C.

Ocean Quahog: Throughout the substrate, at a depth of three feet below the water/sediment interface, within federal waters from the eastern edge of Georges Bank and the Gulf of Maine through out the EEZ, in areas that encompass the top 90% of all ranked ten-minute squares for the area where ocean quahogs were caught in the NEFSC surfclam and ocean quahog surveys. Distribution in the western Atlantic ranges in depths from 30 feet to 800 feet. Ocean quahogs are rarely found where bottom temperatures exceed 60°F, and occur progressively further offshore between Cape Cod and Cape Hatteras (Amendment 12 to the Surfclam and Ocean Quahog FMP, 1998). The ocean quahog EFH designation maps are provided in Appendix C.

Other specific descriptions and identifications of EFHs for commercially significant benthic species within the study area are provided for the following species and corresponding FMPs:

Atlantic Sea Scallop: The designated EFH for the Atlantic Sea Scallop is described in Amendment 9 to the NEFMC's Atlantic Sea Scallop FMP for all life stages. *Eggs*: The designated EFH for sea scallop eggs is the demersal waters north of the Virginia-North Carolina state border from the coast out to the offshore U.S. boundary of the EEZ (Amendment 9 to the Atlantic Sea Scallop FMP, 1998). *Larvae*: The described EFH for sea scallop larvae is the pelagic waters and bottom habitats north of the Virginia-North Carolina state border from the coast out to the offshore U.S. boundary of the EEZ. The substrate where the larvae are most commonly found consists of gravelly sand, shell fragments, and pebbles, or on various red algae, hydroids, amphipod tubes, and bryozoans (Amendment 9 to the Atlantic Sea Scallop FMP, 1998). *Juveniles*: The EFH for juvenile sea scallop is those benthic habitats consisting of cobble, shells, and silt north of the Virginia-North Carolina state border from the coast out to the offshore U.S. boundary of the EEZ (Amendment 9 to the Atlantic Sea Scallop FMP, 1998). Closed areas exist in the Hudson Canyon and Virginia Beach. *Adults*: The designation for adult EFH is bottom habitat with a cobble, shell, or coarse gravelly sand substrate north of the Virginia-North Carolina state border from the coast out to the offshore U.S. boundary of the EEZ (Amendment 9 to the Atlantic Sea Scallop FMP, 1998).

Summer Flounder: The designated EFH for each life stage has been described in Amendment 12 to the MAMFC's Summer Flounder, Scup, and Black Sea Bass FMP of 1998. For all life stages, the EFH has been identified in the highest 90% of all the ranked ten-minute squares for the area where collected in the NEFSC trawl survey. Inshore essential fish habitat and habitat identified not within the study area has been excluded. *Eggs*: The designated EFH for summer flounder eggs north of Cape Hatteras is the pelagic waters found over the Continental Shelf (from the coast out to the limits of the EEZ). The heaviest concentrations are within 9 miles of shore off New Jersey and New York at depths between 30 to 360 feet (Amendment 12 to the Summer Flounder, Scup, and Black Sea Bass FMP, 1998). *Larvae*: EFH for summer flounder larvae north of Cape Hatteras is the pelagic waters found over the Continental Shelf (from the coast to out to the limits of the EEZ). They are most abundant 12-50 miles from shore at depths between 30 to 230 feet (Amendment 12 to the Summer Flounder, Scup, and Black Sea Bass FMP, 1998). *Juveniles*: Designated EFH for juvenile summer flounder north of Cape Hatteras is the demersal waters over the Continental Shelf from the coast outward to the limits of the EEZ (Amendment 12 to the Summer Flounder, Scup, and Black Sea Bass FMP, 1998). *Adults*: The adult EFH is in the demersal waters over the continental shelf from the coast out to the limits of the EEZ. Adults tend to inhabit estuarine and nearshore waters in warmer months but migrate to depths of 500 feet in colder months (Amendment 12 to the Summer Flounder, Scup, and Black Sea Bass FMP, 1998).

Winter Flounder: The EFH for the winter flounder is identified in the NEFMC's Amendment 11 to the Northeast Multispecies FMP and describes the following life stages within the Mid-Atlantic Bight: *Eggs*: The identified EFH for winter flounder eggs is inshore, bottom habitats with sand, muddy sand, mud, and gravel substrates. They are generally found in waters less than 90 meters deep (Amendment 11 to the Northeast Multispecies FMP, 1998). *Larvae*: The EFH is defined as inshore pelagic and bottom waters less than 90 meters deep (Amendment 11 to the Northeast Multispecies FMP, 1998). *Juveniles*: The juvenile EFH for winter flounder is the inshore bottom habitats composed of mud or fine grained sand from George's Bank to Delaware Bay (Amendment 11 to the Northeast Multispecies FMP, 1998). *Adults*: The essential fish habitat for adults is bottom habitats including estuaries to a depth of 100 meters. They prefer mud, sand, and gravel substrates (Amendment 11 to the Northeast Multispecies FMP, 1998).

Channeled and Knobbed Whelk: The whelks are not federally regulated and therefore designation of essential fish habitat is not required by the Magnuson-Stevens Act or the SFA.

Horseshoe Crab: The horseshoe crab is not federally regulated and; designation of EFH is not required by the Magnuson-Stevens Act or the SFA. The ASMFC has developed an interstate FMP for the horseshoe crab and identifies areas of concern that deal with inshore spawning beaches and tidal flat habitats.

2.2.7.5 Marine Mammals

At least twenty-two species of marine mammals, including both pinnipeds and cetaceans, may be found in the study area (Table 2-15) (Waring *et al.* 1999). Additional species may occur as rare visitors, including the hooded seal (*Cystophora cristata*), dwarf and pygmy sperm whales (*Kogia simus*, *K. breviceps*), killer whale (*Orcinus orca*), and the northern bottlenose whale (*Hyperodon ampullatus*). Many marine mammals, in particular whales, are highly migratory and as such may be found throughout the waters of the mid-Atlantic continental shelf. Certain species, such as bottlenose dolphin, are more likely to be found in coastal and inshore waters than other more pelagic species. Brief summaries that focus on habitat, distribution and abundance have been provided for selected species that are relatively abundant or that would likely be encountered in the vicinity of the study area.

Certain areas of the northwestern Atlantic continental shelf are used by marine mammals more often than others, and have been identified as cetacean high-use habitats. Two principal high-use areas are the western margin of the Gulf of Maine and the eastern portion of Georges Bank off Massachusetts, which are outside the project region. The continental shelf edge is a third high-use area throughout the project region. A secondary area of high-use habitat is at midshelf east of the Chesapeake Bay region, particularly for species that feed on fish and squid (teuthivores) (Kenney and Winn 1986). The areas preferred by teuthivores occur throughout much of the study area, whereas piscivorous species are concentrated off the

Table 2-15. Marine Mammals of the Mid-Atlantic Bight

Common Name	Scientific Name	Location w/in Study Area	Habitat(s)
dolphin, bottlenose	*Tursiops truncatus*	throughout	coastal/offshore
dolphin, Clymene	*Stenella clymene*	throughout	open ocean/ island coasts
dolphin, Risso's	*Grampus griscus*	throughout	shelf edge
dolphin, saddleback (common)	*Delphinus delphis*	throughout	offshore shelf
dolphin, spotted- Atlantic	*Stenella frontalis*	throughout	coastal/offshore

dolphin, spotted- pantropical	*Stenella attenuata*	throughout	coastal/ offshore
dolphin, striped	*Stenella coeruleoalba*	throughout	shelf edge
dolphin, whitesided	*Lagenorhynchus acutus*	NJ/ scattered south	offshore to 100m
porpoise, harbor	*Phocoena phocoena*	throughout	inshore/bays, estuaries, harbors
seal, harbor	*Phoca vitulina concolor*	NJ/scattered south	coastal
seal, harp	*Phoca groenlandia*	New Jersey	coastal
whale, blue	*Balaenoptera acutorostrada*	transient throughout	open ocean
whale, Cuvier's beaked	*Ziphius cavirostris*	throughout	coastal/offshore
whale, fin (finback)	*Balaenoptera physalus*	throughout	inshore/offshore
whale, false killer	*Pseudorca crassidens*	MD & south	inshore/offshore
whale, humpback	*Megaptera novaeangliae*	transient throughout	inshore/open ocean
whale, mesoplodont beaked	*Mesoplodon* spp.	throughout	offshore/open ocean
whale, minke	*Balaenoptera acutorostrata*	transient throughout	bays & estuaries/ continental shelf
whale, pilot- long-finned	*Globicephala melas*	NJ & north, scattered south	offshore/ inshore (summer)
whale, pilot -short-finned	*Globicephala macrorhynchus*	NJ & south	coastal/shelf edge
whale, right	*Eubalaena glacialis*	transient throughout	coastal/offshore
whale, sperm	*Physeter macrocephalus*	throughout	offshore shelf

Source: Waring et al. *1999*

coasts of Delaware and Maryland. Patterns of habitat use by cetaceans are seasonal, with intensity of habitat use highest in the spring and summer.

Much of what is known about marine mammal biology is related to their interactions with fisheries. In particular, most information about human-induced mortality comes from data collected by NMFS on net entanglements, vessel collisions and other deaths or serious injuries caused by commercial fishing. Much of the remaining information on sources of marine mammal mortality comes from the data compiled by the various Marine Mammal Stranding Networks that exist in most coastal states in each NMFS region. Other human-related causes of marine mammal mortality include subsistence hunting and illegal poaching, collisions with other types of watercraft, and ingestion of plastic debris or contaminated prey. Other factors that may impede the survival of these species include habitat degradation from chemical pollution, natural resource exploration and coastal development; disturbance or displacement caused by noise; and competition with fisheries. However, it is often difficult to determine a specific disorder when an animal strands itself or is found washed up dead on a beach, and many mortalities, human-related or otherwise, go undetected when animals are not stranded or captured in fisheries. Therefore, an accurate evaluation of the effects of human activities on marine mammal mortality, relative to natural causes of death, often cannot be made.

The National Marine Fisheries Service (NMFS) and U.S. Fish and Wildlife Service (USFWS) have been required under Section 117 of the Marine Mammal Protection Act (MMPA) to prepare "stock assessments" for each "stock" (population) of marine mammal that occurs in waters under the jurisdiction of the United States. These stock assessments contain, among other information, estimates of annual human-caused mortality from all sources, and indicate whether the human-induced mortality is deemed insignificant (approaching a zero mortality and serious injury rate) or significant (more than 10 percent of Potential Biological Removal). When available, this information has been provided for each of the species described in this section.

Non-Listed Species Descriptions

Harbor Seal

The harbor seal may be encountered in coastal areas, bays and estuaries throughout the study area. The range of this species in the east is from southern Greenland and Hudson Bay south to the Carolinas, although their primary distribution is north of New York. The seals move south from the Bay of Fundy in Maine into southern New England and New York waters in autumn and early winter. It is during this time that scattered sightings (or strandings) may occur in coastal waters off New Jersey, Delaware, Maryland and Virginia. They feed on fish and mollusks when the tide comes in, sometimes ascending rivers with the tide. In the spring they may follow fish runs upriver for hundreds of miles, returning to coastal waters in the fall (Amos and Amos 1985). In may, the seals return to Maine for breeding and pupping. The minimum population estimate for this species in the western North Atlantic, based on surveys in 1997, is 30,990 (Waring *et al*. 1999).

Sources of mortality for harbor seals include human interactions (*e.g.*, incidental fishery catch, boat strikes, power plant intake, oil, shootings) and natural causes (*e.g.*, storms, abandonment by mother, and disease). The known fishery-related mortality or serious injury to the western North Atlantic population during 1992-1996 was 898 harbor seals (Waring *et al.* 1999) Annually, small numbers of harbor seals regularly strand throughout their migratory range, although most stranding occurs during the winter period in southern New England and mid-Atlantic regions.

The status of harbor seals in the U.S. Atlantic Exclusive Economic Zone (EEZ) relative to the optimum sustainable population (OSP) is unknown, but the population is increasing. Despite the known fishery-related mortality, the estimated annual rate of increase is 4.4 percent. It is not considered a "strategic stock" by NMFS because human-related mortality and serious injury does not exceed Potential Biological Removal (PBR) (Waring *et al.* 1999). The species is not listed as threatened or endangered under the Endangered Species Act.

Harbor Porpoise

The harbor porpoise is primarily an inshore species. During the summer, harbor porpoises are concentrated in the northern Gulf of Maine and southern Bay of Fundy region, generally in waters less than 150 meters deep. This group of harbor porpoises, which migrates south into the mid-Atlantic region, is considered one population, separate from three other distinct populations in the Gulf of St. Lawrence, Newfoundland, and Greenland areas (Waring *et al*. 1999). During fall (October-December) and spring (April-June), harbor porpoises of this population are widely distributed from New Jersey to Maine. During winter (January to February), intermediate densities of harbor porpoises are found in waters off New Jersey to North Carolina, and low densities are found in waters off New York and north to Canada. No specific migratory routes to the Gulf of Maine/lower Bay of Fundy region have been documented. The best estimate of abundance for the Gulf of Maine/Bay of Fundy population of harbor porpoises is 54,300 (Waring *et al*. 1999).

Harbor porpoises feed on octopus, squid, and fish such as herring. In turn, they are preyed upon by large sharks and killer whales. Because they live mostly inshore, they are often adversely affected by human activities, although they tend to be wary of vessels and do not ride bow waves. The average annual mortality estimate of harbor porpoises for 1992 to 1996 caused by U.S. fisheries (including New England multispecies sink gillnet, Mid-Atlantic coastal gillnet, and Atlantic pelagic drift gillnet fisheries) was 1,667. Sixty-four harbor porpoise strandings were reported from Maine to North Carolina between January and June, 1993. Fifty of those strandings were reported from New York to North Carolina between February and May (Waring *et al.* 1999). Many of the mortalities were caused by net entanglement. Between 1994 and 1996, 107 harbor porpoise carcasses were recovered from beaches in Maryland, Virginia, and North Carolina. Of the 40 harbor porpoises for which cause of death could be established, 25 displayed definitive evidence of entanglement in fishing gear (Waring *et al.* 1999). The total fishery-related mortality is not less than 10% of the calculated PBR, and therefore cannot be considered insignificant and approaching zero mortality and serious injury rate. NMFS considers this a "strategic stock" because annual average human-related mortality and serious injury exceeds PBR (Waring *et al.* 1999).

The status of harbor porpoises, relative to OSP, in the U.S. Atlantic EEZ is unknown. The NMFS has proposed listing the Gulf of Maine population of harbor porpoise as threatened under the Endangered Species Act.

Bottlenose Dolphin

The bottlenose dolphin is common throughout the project area, occuring in both coastal and offshore waters. Coastal and offhore groups of this species are considered to be separate ecotypes. Aerial surveys between Cape Hatteras and Nova Scotia in 1979-1982 suggested a total abundance for all northeast U.S. populations of 10,000 to 13,000 individuals (Kenney 1990). Surveys of the offshore population conducted between Cape Haterras, NC and Nova Scotia in 1991 and between Virginia and the Gulf of St. Lawrence 1995 resulted in population estimates of 12,090-12,760 and 13,453, respectively (Waring *et al*. 1999).

Coastal bottlenose dolphins generally are restricted to waters <25 meters in depth within the northern part of their range (Kenney 1990). The lowest density of coastal bottlenose dolphins was observed over the continental shelf, with higher densities along the coast and near the shelf edge (CeTAP 1982). The coastal population is believed to reside south of Cape Hatteras, NC in the late winter, part of which migrates north of Cape Hatteras to New Jersey in the summer. There may be local, resident populations in certain embayments, and that other transient populations migrate seasonally into and out of these embayments along the eastern seaboard between New York and Florida (Scott *et al*. 1988). Recent information suggests that more than one population does exist along the mid-Atlantic coast (Waring *et al.* 1999). Bottlenose dolphins are a significant component of the marine ecosystem of the entire northeast U.S. continental shelf, consuming over 8 million kg of prey annually (Kenney 1990).

A large die-off of bottlenose dolphins in 1987-1988 may have resulted in a 50 percent or greater decline in the coastal population. Bottlenose dolphins are the most frequently stranded small cetaceans along the Atlantic coast, and many of the animals show signs of human-induced injury. A survey of the nearshore environment from New Jersey to Cape Hatteras in 1987 resulted in an abundance estimate of 1,050 to 7,500 dolphins. An aerial survey in July 1994 of the same area resulted in an abundance estimate of 12,570 dolphins. The coastal type of the bottlenose dolphin has been classified as depleted under the MMPA (NMFS 1992; Waring *et al*. 1999).

Common (Saddleback) Dolphin

The common dolphin may be one of the most widely distributed species of cetaceans, as it is found world-wide in temperate, tropical, and subtropical seas. In the western North Atlantic, common dolphins are found over the continental shelf along the 200-300m isobaths or over prominent underwater topography from 50° N to 40° S latitude. They are also distributed in broad bands along the continental slope from 100 to 2,000 meters (Waring *et al*. 1999). The species is less common south of Cape Hatteras, NC. From mid-January to May, common dolphins are widespread in outer continental shelf waters from Cape Hatteras northeast to Georges Bank. They move further north onto Georges Bank and the Scotian Shelf from mid-summer to autumn (CeTAP 1982). The best available current abundance estimate for common dolphins in the western North Atlantic is 22,215 as derived from a June-July 1991 line transect survey that provided the most complete coverage of known habitat between Cape Hatteras and Georges Bank (Waring *et al*. 1999).

Human-induced mortality for this species of dolphin is primarily related to the fishery industry, including incidental catch in gillnets and trawls. The total annual estimated fishery-related mortality to the western North Atlantic population during 1992-1996 was 247 common dolphins (Waring *et al.* 1999). From 1992-1996, 42 common dolphins were stranded between North Carolina and Massachusetts, predominantly along Massachusetts beaches. Causes of mortality to these stranded dolphins is unknown. Common dolphins are not listed as threatened or endangered under the Endangered Species Act, but are considered to be a "strategic stock" by NMFS because average annual fishery-related mortality and serious injury exceeds PBR (Waring *et al.* 1999).

Spotted Dolphin

There are two species of spotted dolphin in the Western Atlantic: the Atlantic spotted dolphin and the pantropical spotted dolphin. These two species are difficult to differentiate at sea, but the pantropical spotted dolphin favors tropical and sub-tropical oceans. Atlantic spotted dolphins are distributed in tropical and warm temperate waters of the western North Atlantic. The Atlantic spotted dolphin's range is from southern New England, south through the Gulf of Mexico and the Caribbean to Venezuela. Off the northeast U.S. coast, spotted dolphins are widely distributed on the continental shelf, along the shelf edge, and offshore over the deep ocean south of 40° N (CeTAP 1982). Atlantic spotted dolphins regularly inhabit the inshore waters south of the Chesapeake Bay and near the continental shelf edge and slope waters north of this region. They may occur in herds of several thousand, but smaller groups are more common. Population estimates lump both species of spotted dolphin together because of the difficulty in distinguishing the two species. The best available current abundance estimate for the undifferentiated group of spotted dolphins in the western North Atlantic is 4,772, as derived from the July to September 1995 line transect survey between Virginia and the Gulf of St. Lawrence (Waring *et al*. 1999).

Primary sources of mortality for these species of dolphins are unknown. Total annual estimated average fishery-related mortality to this stock during 1992-1996 was 16 spotted dolphins (*Stenella* sp.). From 1995-1996, six Atlantic spotted dolphins and 15 Pantropical spotted dolphins were stranded between North Carolina and Florida. The 15 mortalities includes a mass stranding in Florida in 1996 of 11 Pantropical spotted dolphins (NMFS unpublished data). The cause of the strandings are unknown, nor is the status of spotted dolphins relative to OSP in the U.S. Atlantic EEZ . Neither species is listed as threatened or endangered under the Endangered Species Act, but both are considered to be a "strategic stock" by MFS because average annual fishery-related mortality and serious injury exceeds PBR (Waring *et al.* 1999).

Minke Whale

Minke whales have a cosmopolitan distribution in polar, temperate and tropical waters. The minke whale is the third most abundant large whale in the U.S. Atlantic EEZ (CeTAP 1982). In the North Atlantic there are four recognized populations. Minke whales off the east coast of the U.S. are part of the Canadian east coast population. This species is found in open seas primarily over continental shelf waters, but occasionally enters bays, inlets and estuaries. The range of this minke whale population extends south from Canada to the Gulf of Mexico, but distribution is primarily concentrated in New England waters. The

best available current abundance estimate for minke whales in the western North Atlantic is 2,790, from surveys conducted in 1995 (Waring *et al*. 1999).

Minke whale incidental catches have been observed in U.S. waters in the New England multispecies sink gillnet, Atlantic pelagic drift gillnet, bluefin tuna purse seine fisheries, and in fish weirs, although not all catches have resulted in mortality. The annual mortality estimate from these fisheries from 1992 to 1996 is 0.8 minke whales per year (Waring *et al.* 1999). Other human-induced mortality occurs from hunting, to which this species is subject in areas of the North Atlantic, and collisions with vessels, because minke whales inhabit coastal waters during much of the year. The minke whale is not listed as threatened or endangered under the Endangered Species Act, depleted under the MMPA, or as a strategic stock by NMFS.

Pilot whale

Two species of pilot whales occur in the North Atlantic, the shortfin pilot whale in the south, and the longfin in the north. The range of the two species overlaps seasonally in the Mid-Atlantic between New Jersey and Cape Hatteras such that anything north of New Jersey is likely the longfin pilot (Waring *et al*. 1999). Pilot whales are generally distributed along the continental shelf edge in the winter and early spring off the northeast U.S. coast. In the summer, long-finned pilot whales inhabit inshore waters and bays. Short-finned pilot whales also may be found in coastal areas in the summer. Both species of pilot whales typically inhabit areas of high relief or submerged banks. They are also associated with the Gulf Stream north wall and thermal fronts along the continental shelf edge (CeTAP 1982). These species feed on herring, mackeral and squid, among other prey.

The longfin pilot whale occurs northward into Canadian and Greenland waters and eastward to Europe, and is subject to an ongoing harvest around the Faroe Islands and incidental capture in several fisheries in U.S. and Canadian waters. The shortfin pilot whale may be subject to a low level of bycatch in several U.S. fisheries. Total annual estimated average fishery-related mortality (1992-1996) was 32 pilot whales. Population structure and general life history of both species is very poorly known. The most recent survey (summer 1995) for both species of pilot whales between Virginia and the Gulf of St. Lawrence resulted in an abundance estimate of 8,176 (Waring *et al*. 1999).

Pilot whales have a tendency to strand throughout their range, but the influence of human activities on these strandings is unknown. From 1992-1996, 60 long-finned pilot whales stranded between South Carolina and Maine, including 22 animals that mass stranded along the Massachusetts coast in 1992. From 1992-1995, eight short-finned pilot whales stranded along beaches between Virginia and New Jersey. A potential human-caused source of mortality is from PCBs and DDT, moderate levels of which have been found in pilot whale blubber. These species are not listed as threatened or endangered under the ESA. Short-finned pilot whales are considered a strategic stock by NMFS because estimated average fishery-related mortality exceeds PBR (Waring *et al.* 1999).

Threatened and Endangered Marine Mammals

Eleven species of marine mammals in U.S. waters are listed as threatened or endangered. Endangered species are the blue, bowhead, fin, humpback, right, sei, and sperm whales, and the Caribbean monk and Hawaiian monk seals. The Guadalupe fur seal and Steller sea lion are listed as threatened. The cetaceans are protected under the jurisdiction of the NMFS, while the pinnipeds are protected under joint jurisdiction of the NMFS and USFWS. The blue, fin, humpback, right, and sperm whales may be encountered in the project area(s), but only the fin, humpback and sperm whales appear to use this region to any great extent. The other species which use this region are primarily transients migrating between southern winter calving areas and more northerly summer feeding, nursery and mating grounds (CeTAP 1982, Brosius *et al.* 1983). The seasonal distributions of humpback, fin and sperm whales in the mid-Atlantic bight are depicted in Figure 2-83. Species accounts are given below.

Blue Whale

The distribution of the blue whale in the north Atlantic extends from the Arctic to at least the mid-latitudes (Waring *et al*. 1999). The blue whale is considered an occasional visitor to the U.S. Atlantic EEZ, which may be the current southern limit of its range (CeTAP 1982, Waring *et al*. 1999), although the species has been documented as far south as Florida and the Gulf of Mexico (Yochem and Leatherwood 1985). Blue whales are highly migratory surface feeders that eat krill and small-sized schooling fish and prefer open ocean habitats. The blue whale was listed as endangered throughout its range on June 2, 1970. This species is depleted in all oceans of the world, and with the exception of the Gulf of St. Lawrence population with 308 documented individuals (Waring *et al*. 1999), the population status of this species is unknown.

There are no confirmed records of mortality or serious injury to blue whales in the U.S. Atlantic EEZ. However, in March 1998 a dead 66-foot male blue whale was brought into Rhode Island on the bow of a tanker. The cause of death was determined to be a ship strike that occurred somewhere to the north of the U.S. EEZ (Waring *et al*. 1999). Blue whales are considered to be a strategic stock by NMFS because of the listing status under the Endangered Species Act.

Fin Whale

Fin whales are probably the most numerous large cetaceans in temperate waters of the western North Atlantic. They accounted for 46 percent of the large whales and 24 percent of all cetaceans sighted over the continental shelf during an aerial survey program (CeTAP 1982; Hain *et al.* 1992). Fin whales range widely throughout the continental shelf in all seasons, principally from Cape Hatteras northward, but are

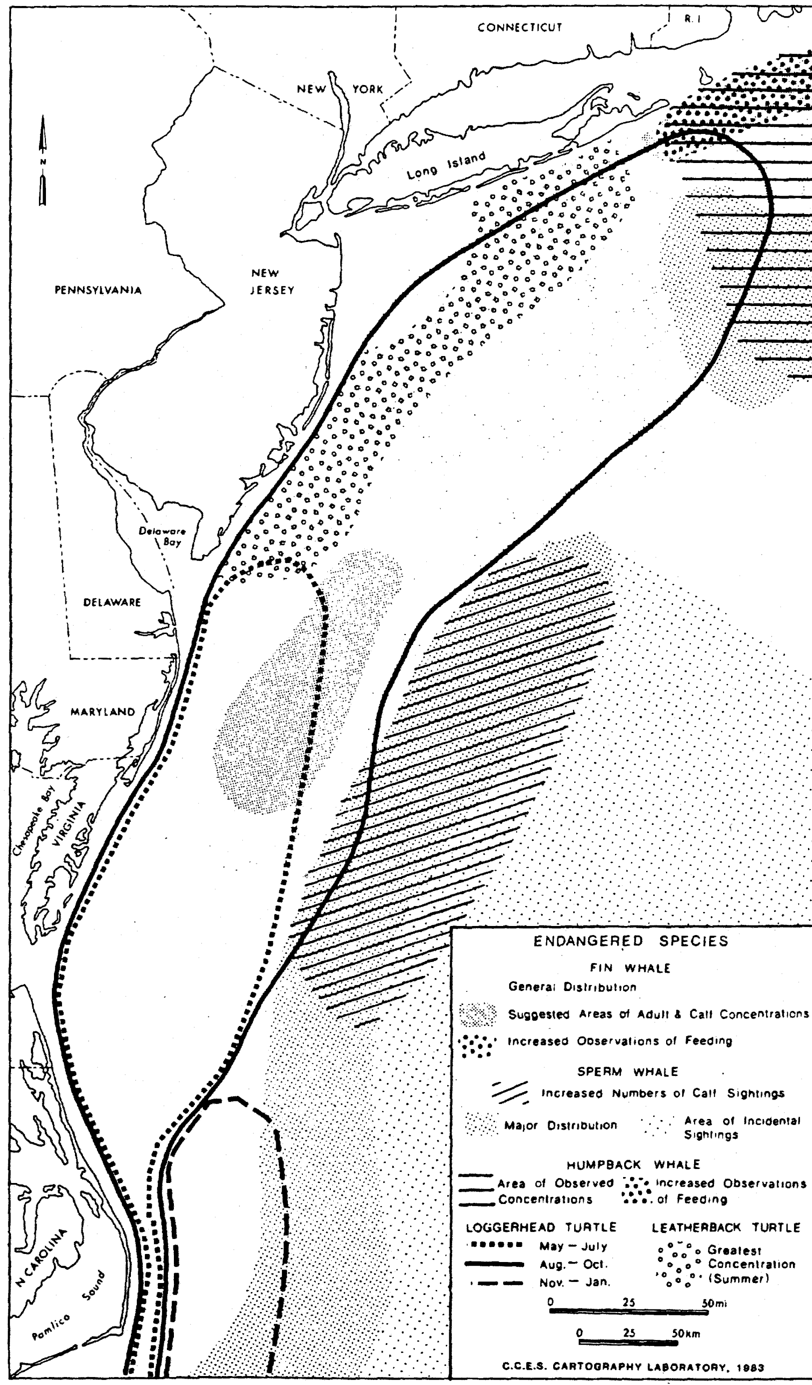


Figure 2-83. Endangered and threatened species distributions in the Mid-Atlantic Bight (from Brosius *et al.* 1983).

most commonly sighted from Cape Cod, Massachusetts north through the Gulf of Maine (NMFS 1992; Waring *et al*. 1999). The most important habitat identified in the CeTAP surveys was a large arc extending from the Great South Channel (east of Nantucket) along the 50m isobath past Cape Cod, Massachussetts and over Stellwagen Bank (Hain *et al.* 1992). Other areas of importance included the mid-shelf in the mid-Atlantic bight.

Spring was the season of greatest abundance and widest occupation (Hain *et al.* 1992). A population size of 4,680 was estimated from aerial surveys conducted from 1978 to 1982 on the continental shelf and shelf edge waters between Cape Hatteras, N.C. and Nova Scotia (CeTAP 1982). The best available current abundance estimate for the western North Atlantic fin whale is 2,700 (Waring *et al*. 1999). The fin whale was listed as endangered throughout its range on June 2, 1970. The present world population estimate is 120,000 individuals, reduced from over 700,000 early in the century (NMFS 1998b).

Between 1991 and 1996, only one reported fin-whale mortality involved fishery entanglement, and two others involved collisions with vessels. Based on this data, annual human-caused mortality and serious injury to fin whales is estimated as 0.5 per year. However, this can only be interpreted as being the minimum level of human-caused mortality, because it is highly likely that additional serious injuries and mortalities go unreported (Waring *et al.* 1999). Any fishery-related mortality is illegal because there is no recovery plan currently in place for this species, although a draft plan is currently in review. Fin whales are considered a strategic stock by NMFS because they are listed as endangered under ESA.

<u>Humpback Whale</u>

Humpback whale distribution is linked primarily to feeding areas. In the summer, humpback whales aggregate in five distinct feeding locations in the North Atlantic. These are the Gulf of Maine, Gulf of St. Lawrence, Newfoundland and Labrador, Greenland, and the Iceland-Denmark Straight (Waring *et al*. 1999). Humpback whales are typically piscivorous while in New England waters, feeding on herring, sand lance, and other small fishes (including capelin, mackerel, pollock, haddock and krill). Their distribution has been largely correlated to the abundance and distribution of these prey species. For example, commercial depletion of herring and mackerel led to an increase in sand lance in the southwestern Gulf of Maine in the mid 1970's, with a concurrent decrease in humpback whale abundance in the northern Gulf of Maine. The whales shifted their distribution to the sandy shoals favored by the sand lance in the southwestern Gulf of Maine during much of the late 1970s and early 1980s. When a major influx of herring occurred in the northern Gulf of Maine in 1992-1993, humpback whale abundance in this area increased dramatically (Waring *et al.* 1999). Throughout the spring, summer, and fall feeding seasons, the Gulf of Maine population may have individuals scattered southward along the eastern coast of the United States. In recent years the number of sightings of young humpbacks in the mid-Atlantic region has increased, generally in the areas of the Chesapeake and Delaware Bays. Strandings of juvenile humpback whale also have increased along the Virginia and North Carolina coasts, indicating that the mid-Atlantic region supports important habitat for this stage the humpback's life, and that human impacts are negatively affecting this species. In the winter, humpbacks migrate from feeding areas to breeding and calving grounds in the Caribbean, passing through the entire project area during their journey. There have also been a number of wintertime sightings in coastal waters of the southeastern U.S. Whether the increased sightings represent a distributional change, or are simply due to an increase in sighting effort and/or whale abundance, is presently unknown (Waring *et al.* 1999).

The best available current abundance estimate for the western North Atlantic humpback whale is 10,600 (Waring *et al*. 1999). Human impacts (especially vessel collisions and fishery entanglements) are factors which may be slowing recovery of the humpback whale population. There is an average of four to six entanglements of humpback whales per year in the Gulf of Maine, and additional reports of vessel-collision scars. It has been suggested that injury and deaths from vessel collisions are more common and serious than entanglements with fishing gear. Between November 1987 and January 1988, 14 humpback whales died after consuming Atlantic mackerel containing a dinoflagellate saxitoxin. It is highly likely that other mortalities occurred during this time period that went unrecorded. During the first six months of 1990, seven dead juvenile humpbacks stranded between North Carolina and New Jersey. The cause of these strandings is unknown. For the period 1991 to 1996, the total estimated human caused mortality and serious injury to humpback whales is estimated as 5.7 per year, which must be considered a minimum estimate (Waring *et al*. 1999). The total level of human-caused mortality and serious injury is unknown, but current data indicate that it is significant.

The humpback whale North Atlantic population is considered to be low relative to OSP in the U.S. Atlantic EEZ, and it is considered a strategic stock by NMFS. Humpback whales are listed as endangered under the Endangered Species Act, and a Recovery Plan has been published and is in effect.

Right Whale

Northern right whales of the western North Atlantic population occur on the continental shelf from Florida to Nova Scotia. Individuals of this population migrate from wintering and calving grounds in coastal waters of the southeastern United States to summer feeding, nursery, and mating grounds in New England waters and northward to the Bay of Fundy and the Scotian Shelf. Five major congregation areas are used by this species. These are coastal Florida and Georgia, the Great South Channel east of Cape Cod, Cape Cod and Massachusetts Bay, the Bay of Fundy, and Browns and Baccaro Banks south of Nova Scotia. Movements within and between these high-use areas may be fairly extensive. The distribution of right whales is likely determined by the distribution of their prey, the preferred of which is a copepod species known as *Calanus finmarchicus*. In the congregation areas, right whales distribute themselves in 100 to 150 m of water depth usually near steep bottom slopes. Preliminary studies suggest that, at least in the Great South Channel, this is a zone of complex physical and biological processes with fronts, upwelling, and very high concentrations of *C. finmarchicus* (Winn *et al.* 1986).

The current worldwide abundance estimate for this species is 500 individuals, 295 of which are from the North Atlantic population (NMFS 1991; Waring *et al*. 1999). The pre-eighteenth century population may have been as high as 10,000, in which case the current population is more than 95 percent depleted.

Approximately one third of all right whale mortality is caused by human activities. The small population size of this species and low annual reproductive rate suggest that human sources of mortality may have a greater effect on population growth rates than for other whales. This whale’s habit of resting at the surface, surface skim-feeding and surface courtship groups makes it particularly susceptible to ship collisions, which is a primary cause of serious injury and death. Entanglement with fishing gear is secondary to collisions with vessels. Reported human-caused mortality and serious injury has been a minimum of 2.3 right whales per year since 1991. This species is listed as endangered under the ESA. A Recovery Plan has been published and is in effect. Three critical habitats, Cape Cod Bay/Massachusetts Bay, Great South Channel, and the Southeastern U.S. (Georgia and Florida) were designated by NMFS. This is a strategic stock because the average annual fishery-related mortality and serious injury is not less than 10% of the PBR, and because the North Atlantic right whale is an endangered species (Waring *et al.* 1999).

Sperm Whale

Sperm whales inhabit all oceans of the world, but are found primarily in temperate and tropical waters. Sperm whales tend to inhabit areas with a water depth of 600 meters or more, and are uncommon in waters less than 300 meters deep. Their distribution is dependent on their food source, which is primarily squid, and suitable conditions for breeding, and varies with the sex and age composition of the group. The distribution of the sperm whale in the U.S. EEZ occurs on the continental shelf edge, over the continental slope, and into mid-ocean regions (Waring *et al*. 1999). There appear to be distinct seasonal cycles to sperm whale distributions in the mid-Atlantic (CeTAP 1982; Waring *et al*. 1999). In winter, sperm whales are concentrated east and northeast of Cape Hatteras, NC. In spring, the center of distribution shifts northward to east of Delaware and Virginia, and is widespread throughout the central portion of the mid-Atlantic bight and the southern portion of Georges Bank. In summer, distribution is similar but also includes the area east and north of Georges Bank and the Northeast Channel region, as well as the continental shelf (inshore of the 100m isobath) sourth of New England. In the fall, sperm whale occurrence south of New England on the continental shelf is at its highest level, and there remains a continental shelf occurrence in the mid-Atlantic bight (CeTAP 1982).

The sperm whale was listed as endangered throughout its range on June 2, 1970. The sperm whale is the most abundant of all the endangered whales, with an estimated worldwide population of two million individuals (NMFS 1984). However, due to dramatic declines caused by commercial whaling, they are still considered endangered. The best available current abundance estimate for the western North Atlantic sperm whale as estimated from a July to September 1995 line transect survey of continental shelf edge and continental slope waters between Virginia and the Gulf of St. Lawrence is 2,698 (Waring *et al*. 1999). Sperm whales are less likely to be impacted by humans, and those impacts are less likely to be recorded, because of their general offshore distribution. Total annual estimated average fishery-related mortality or serious injury to this stock during 1992-1996 was zero sperm whales. However, in 1995 one sperm whale was entangled in a pelagic gill driftnet and released alive with gear around several body parts, an incident that was not used to calculate serious injury or mortality (Waring *et al.* 1999). Six sperm whale strandings were documented along the Atlantic coast between Maine and Florida during 1994-1996 (NMFS 1998a, unpublished data). The status of this population relative to the OSP in the U.S. Atlantic EEZ is unknown, but it is considered a strategic stock by NMFS because it is an endangered species.

2.2.7.6 Sea Turtles

Five species of sea turtle may be found in the study area. In order of frequency of occurrence, these are the loggerhead (*Caretta caretta*), leatherback (*Dermochelys coriacea*), Kemp's (Atlantic) ridley (*Lepidochelys kempi*), green (*Chelonia mydas*), and hawksbill (*Eretemochelys imbricata*) turtles (NMFS/USFWS 1995). Sea turtles are highly migratory creatures, and as such may be encountered throughout the Mid-Atlantic continental shelf waters and in coastal areas. Specific migratory patterns of adult sea turtles are the subject of much ongoing research and the locations of marine turtles in the open ocean are not precisely known, with the exception of individuals tracked via satellite telemetry. However, seasoned coastal concentrations of particular species do occur within the project area. Hatchling turtles are thought to drift in open ocean currents, finding food and cover in the driftlines that form where ocean currents converge and sink. At some point in their development, young turtles leave the open ocean and take up residence in shallower coastal waters. The bays, estuaries, and nearshore coastal waters of the U.S. east coast and Gulf of Mexico provide important developmental habitat for juvenile and subadult sea turtles. Once maturity is reached, most sea turtles move to permanent feeding grounds or through a series of feeding areas. Several species use the Chesapeake Bay as a summer foraging area. An estimated 5,000 to 10,000 sea turtles can be found in the lower Bay off Virginia during the summer months (VDEQ 1997). Sea turtle activity during the summer months (late June-October) is also common along the inshore waters and back bays of New Jersey. Species such as loggerhead, Kemp's ridley, and green have been commonly observed foraging along the coast and back bay shallows (B. Schoelkopf, NJ Marine Mammal Stranding Center, pers. comm.). A map depicting the seasonal distributions of loggerhead and leatherback turtles, the two most common species of sea turtle in the mid-Atlantic bight, is shown as Figure 2-83.

Most sea turtles do not nest near their feeding areas and migrate great distances to their nesting beaches. All sea turtles come ashore to lay their eggs. Nesting on the east coast has been recorded as far north as New Jersey, Maryland and Virginia, but most nesting in the U.S. occurs in the southeastern states of Florida, Georgia and the Carolinas (Van Meter 1992).

The survival of sea turtle populations around the world are threatened by human impacts. Although each species of sea turtle is biologically different, sea turtles share many general life history characteristics (such as nesting on land; producing large numbers of independent young) that make these creatures susceptible to many of the same sources of human-induced mortality. Compared with natural causes, human impacts are an overwhelmingly significant factor in sea turtle mortality (Bjorndal 1996; Lutcavage *et al.* 1996). Natural causes of sea turtle mortality include predation on eggs and hatchlings, nest destruction by tidal inundation or plant roots invasion, and fibropapillomatosis, the primary disease that affects turtles in the wild (NRC 1990; George 1996). Adult sea turtles have very few natural predators, other than large sharks and killer whales. Anthropogenic mortality factors include egg harvesting, direct (illegal) hunting, incidental capture in shrimp trawls and fishing gear, ingestion of plastic debris, habitat alteration and loss, oil pollution, exotic predator species, and boat strikes and underwater explosions (Lutcavage *et al.* 1996). All species of marine turtle found in the area are listed as federally threatened or endangered, and are protected under joint jurisdiction of the USFWS and NMFS.

<u>Loggerhead</u>

Loggerheads inhabit continental shelves, bays, estuaries, and lagoons in temperate, subtropical, and tropical waters. In the Atlantic, the loggerhead's range extends from Newfoundland to as far south as Argentina. Loggerheads forage along the inshore and coastal waters of the Gulf of Mexico, the Florida Keys and north along the eastern seaboard as far as New England. Thousands of sub-adult loggerhead turtles forage on horseshoe crabs in the Chesapeake Bay during the summer months (Keinath *et al*. 1987).

The greatest concentrations of loggerheads in the mid-Atlantic area, from surveys conducted between 1978 and 1982 and more recent sightings, were observed in the summer (CeTAP 1982; Shoop and Kenney 1992). Between June and October, foraging juvenile and sub-adult loggerheads are a comon occurrence in the inshore coastal waters and back bays of all states in the project region. During the month of May, an estimated 4,500 loggerheads migrate from the south around Cape Hatteras, N.C. to northern feeding areas (Keinath *et al*. 1996). The turtles return south in the fall, rounding the Cape in October and November. During these migrations the turtles tend to follow inshore routes (Keinath *et al*. 1996).

Loggerheads mate offshore between late March and early June, and eggs are laid throughout the summer. During the nesting season adult females remain in shallow areas near their nesting beaches. An estimated 20,000-28,000 female loggerheads nest in the southeastern U.S. annually (NMFS/USFWS 1991a, 1995). The primary Atlantic nesting sites are along the east coast of Florida, with additional sites in Georgia, the Carolinas, and occasionally Virginia. Loggerheads will sometimes, although rarely, nest on Assateugue Island off the coast of Maryland (USACE 1998a, 1998b). In 1998, a loggerhead false crawl was documented on the Maryland side of Assateague Island (S. Ramsey, Assateague National Park, pers. comm.). In Virginia, up to 10 loggerhead nests per year are documented on oceanside beaches from Cape Henry to the North Carolina Border, including Dam Neck and those on the Back Bay National Wildlife Refuge at the head of the Outer Banks. Back Bay NWR documented two loggerhead nests on its beaches in 1998 (L. Johnson, BBNWR, pers comm). The Chincoteague NWR in Virginia typically documents about one loggerhead nest every three to five years (S. Ramsey, pers. comm.). Anecdotal evidence from the mid-1980's cites a loggerhead false crawl on a Delaware beach (E. Stetzar, DNREC Stranding Network, pers. comm.). In New Jersey, a loggerhead nested in Ocean City in the mid- 1970's, and other nesting areas have included Little Beach Island, located between Brigantine and Long Beach Island, Island Beach State Park, and Seaside Heights. Most of these nestings occurred in mid to late summer. Current trends indicate that over the last 20-30 years the population has declined rapidly on nesting beaches in the Carolinas and Georgia (NMFS/USFWS 1995). The loggerhead turtle was listed as threatened throughout its range on June 2, 1970.

<u>Leatherback</u>

The leatherback is the largest and most highly specialized sea turtle. The leatherback turtle's range in the Atlantic extends from Cape Sable, Nova Scotia south to Puerto Rico and the U.S. Virgin Islands. While leatherbacks venture into some of the deepest and coldest regions of the ocean, they also inhabit relatively shallow coastal waters along the eastern seaboard of the Atlantic. The leatherback feeds almost exclusively on jellyfish. During the summer, leatherbacks are found along the east coast of the U.S. from the Gulf of Maine south to the middle of Florida. During a 1978 to 1982 survey, leatherback sightings in the mid-Atlantic region were far fewer in number than loggerheads. A concentration appeared near Long Island, with a less dense concentration to the east of New Jersey. The greatest number of sightings of leatherbacks occurred during the summer months (CeTAP 1982; Shoop and Kenney 1992).

The leatherback is known to travel up to 3100 miles (5000 km) from its nesting beaches. Nesting occurs from February to July with nest sites along Atlantic coasts from Georgia to the U.S. Virgin Islands. In 1996, a leatherback false crawl was documented on Assateague in Maryland. Nesting populations of leatherbacks are difficult to determine because females frequently change beaches. Currently, it is estimated that 20,000 to 30,000 female leatherbacks exist worldwide (NMFS/USFWS 1995). The leatherback was listed as endangered throughout its range on June 2, 1970.

Kemp's Ridley

Kemp's ridley is the smallest and rarest species of marine turtle. It is currently estimated that the nesting population consists of 500 adult females (NMFS/USFWS 1995). Adults are found primarily in the Gulf of Mexico, but juvenile and subadult Kemp's ridleys are widely distributed throughout coastal waters of the U.S. from Texas to Maine. An estimated 500 Kemp's ridley sea turtles migrate from the south around Cape Hatteras during May to northern summer feeding areas such as the Chesapeake Bay and coastal waters of Virginia and New Jersey (Keinath *et al*. 1996; Lutcavage and Musick 1985). During these migrations the turtles tend to follow inshore routes (Keinath *et al*. 1996). Kemp's ridley turtles are carnivorous, feeding on crabs and other crustaceans, clams, mussels, fish and jellyfish. Blue crab is the preferred food in many areas (Van Meter 1992). In the winter, Kemp's ridleys in northern areas migrate south to Florida and the Gulf of Mexico, rounding Cape Hatteras in October and November. Most nesting by this species is restricted to a 20-mile stretch of beach along the western Gulf of Mexico. Kemp's ridley was listed as endangered throughout its range on December 2, 1970.

Green

In the southeastern United States, green turtles are found around the U.S. Virgin Islands, Puerto Rico, and the continental U.S. from Texas to Massachusetts. This turtle is primarily a tropical species, but like all sea turtles is highly migratory and may be found anywhere throughout the waters of the mid-Atlantic continental shelf. In the summer, green turtles have ben found in estuarine waters as far north as Long island Sound and the Chesapeake Bay (Lutz and Musick 1996). Green turtle habitat includes broad expanses of shallow, sandy flats covered with seagrasses or in areas where seaweed can be found. Scattered rocks, bars and coral heads are used as nighttime sleeping sites. Individual turtles have particular sleeping shelters to which they return every night (Van Meter 1992). Juvenile and sub-adult green turtles are carnivorous, feeding on such things as jellyfish, but adult green turtles are unique in being herbivores that feed on algae and seagrasses. Green turtles rarely nest north of Little Cumberland Island off the coast of Georgia (NMFS/USFWS 1991b). The green turtle was listed as endangered in Florida and the Pacific coast of Mexico and threatened throughout the rest of its range on July 28, 1978.

Hawksbill

The hawksbill may be the most tropical of all marine turtles. Although it may occasionally stray into colder waters, this species usually is found in coastal reefs, estuaries, bays and lagoons of tropical and subtropical Atlantic, Pacific, and Indian Oceans. Within the United States, hawksbills are most common in Puerto Rico and its associated islands and in the U.S. Virgin Islands. In the continental U.S., this species is recorded from all the gulf states and from along the eastern seaboard as far north as Massachusetts, with the exception of Connecticut, but sightings north of Florida are extremely rare (Shoop and Kenney 1992). Coral reefs are widely recognized as the residential foraging habitat of juveniles, subadults and adults, due to their primary diet of sponges. The ledges and caves found in reefs provide shelter for daytime and nighttime resting. Hawksbills are also found around rocky outcrops and high energy shoals, which are also optimum sites for sponge growth (NMFS/USFWS 1993). Hawksbills are also known to inhabit mangrove-fringed bays and estuaries, particularly along the eastern shore of continents where coral reefs are absent. In Texas, juvenile hawksbills are associated with stone jetties (NMFS/USFWS 1993). This type of structure could potentially harbor hawksbills in other areas. Small isolated beaches, often on offshore islands, are favored as nest sites. Because hawksbills are small and agile, they can exploit nesting areas that may be inaccessible for other species of sea turtle. Within the continental U.S., nesting is restricted to the southeast coast of Florida and the Florida Keys. The hawksbill was listed as endangered throughout its range in 1970 (NMFS/USFWS 1995).

2.2.7.7 Threatened and Endangered Species

Eleven endangered or threatened species (five cetaceans, five marine turtles, and one anadromous fish) are known to occur in the Mid-Atlantic continental shelf area. These species include the blue, fin, humpback, right, and sperm whales; loggerhead, green, Kemp's (Atlantic) ridley, leatherback, and hawksbill turtles; and the anadromous shortnose sturgeon. Additionally, the sand tiger shark has been a candidate species under the Endangered Species Act since 1997 and NMFS will conduct a status review when funding becomes available. Since spawning by the shark may be conducted in the southerly regions of the study area, a brief description of the sand tiger's geographical range and preferred habitat has been included within this section. The cetaceans and shark are protected under the jurisdiction of NMFS, whereas the sea turtles and the anadromous fish are protected under the joint jurisdiction of NMFS and USFWS. The cetaceans and marine turtles have been described in the previous sections.

Shortnose Sturgeon

The shortnose sturgeon was listed as endangered throughout its range on March 11, 1967. This species is anadramous, spawning in rivers along the east coast of North America from Canada to Florida. The shortnose sturgeon is found in nearshore marine, estuarine, and riverine habitats of large river systems. Shortnose sturgeon, unlike some other anadromous species in the region, do not appear to make long distance offshore migrations. These fish are benthic feeders, feeding on insect larvae as juveniles and mollusks and large crustaceans as adults. No estimate of the historic abundance of shortnose sturgeon is available, as commercial fisheries did not differentiate this species from Atlantic sturgeon. The decline of this species is attributed to dams, commercial exploitation, pollution and habitat loss and degradation. Current population sizes are the subject of ongoing research as part of the 1998 shortnose sturgeon recovery plan (NMFS/USFWS 1998).

Sand Tiger Shark

The range of the sand tiger shark extends from the Gulf of Maine to southern Brazil, and from western Florida to Texas. It is locally abundant off the coast of North Carolina, particularly at the site of a shipwreck 18 miles south of Cape Lookout. This species inhabits shallow inshore waters, staying on or close to the bottom. In April 1997, the U.S. Atlantic Shark Fisheries Management Plan was adopted as a final rule by the NMFS, prohibiting directed fishing of this and several other species of sharks.

2.2.8 Socioeconomic Environment

The Mid-Atlantic region of the United States constitutes a significant, coastal stretch of the eastern Atlantic seaboard. The convenient accessibility and close proximity to the Atlantic Ocean and associated beaches has produced a socioeconomic environment that relies heavily upon its coastal and marine resources. The activities of the Mid-Atlantic region population are both historically and currently linked to these natural and manmade assets of the Mid-Atlantic Bight and its adjacent bays and waters.

Currently, the total population for the coastal regions of the Mid-Atlantic States, the Chesapeake and Delaware Bays, and the lower extremities of their major tributaries (Potomac, James, and Delaware Rivers) is estimated at 13,600,000 (USBC, Population Estimates for 1997). This population total excludes the New York City metropolitan areas of New York State. Another 1,186,220 people reside in the metropolitan areas of Washington D.C and Baltimore, Maryland, with highest population densities occurring in the Washington D.C./Baltimore metropolitan areas and the Hampton Roads area of the James River in southeastern Virginia (USBC, Population Estimates for 1997).

The following section presents information on the socioeconomic environment of the Mid-Atlantic region and its surrounding waters, including commercial and recreational fisheries, archaeological/cultural resources, habitat enhancement structures, undersea infrastructure, shipping and navigation, military usage, and dredged material disposal sites.

2.2.8.1 Commercial and Recreational Fisheries

Commercial and recreational fishermen target similar marine species, but the catch per unit effort varies due to varied gear type, catch strategies, and differences in species regulations and limits between the two. Recreational anglers rely heavily on hook and line, whereas commercial fisheries implement a myriad of gear types to harvest their targeted species. The major commercial gear types include otter trawls, gill nets, purse seines, and dredges. The commercial and recreational fishing industries of the Mid-Atlantic region are vital to the continued value and socioeconomic development of the coastal population and adjacent inshore populations. The combination of coastal heritage and the continuing harvest of its marine resources continue to link this region to its waterways and shoreline facilities.

Species of commercial importance have been classified under one of five categories based on their migratory patterns, location in the water column, or general habitat. These categories are the demersal, anadromous/pelagic, pelagic, catadramous, and shellfish fisheries. The shellfish fishery is technically a subdivision of the demersal fishery but has been separated into its own category for clarification purposes. Commercially important species managed in the Mid-Atlantic region under the Magnuson-Stevens Fishery Conservation and Management Act and the Sustainable Fisheries Act of 1996 are summer flounder, winter flounder, scup, black sea bass, Atlantic surfclam, ocean quahog, red hake, goosefish, sea scallop, Atlantic herring, Atlantic mackerel, squid, bluefish and butterfish. Species within state waters are managed and regulated by state bureaus under recommendation of National Marine Fisheries Service (NMFS), Atlantic States Marine Fisheries Commission (ASMFC) FMPs, and the designated fishery councils. These species include blue crab, menhaden, striped bass, conch (whelk), American shad, American eel, and tautog. Jurisdiction of recreationally important species overlap with some of the commercial fisheries and include anadromous species like the striped bass, weakfish, red drum, and bluefish. Demersal species such as winter

and summer flounder, scup, tautog, hake, black sea bass, and blue crab are targeted both recreationally and commercially.

2.2.8.1.1 Commercial Fishery

As prescribed by the Magnuson-Stevens Fishery Conservation and Management Act (Magnuson-Stevens Act), commercial fisheries are regulated and managed in federal waters (3-200 nautical miles offshore) by eight regionally-established fishery management councils. Of these eight councils, the New England Fishery Management Council, Mid-Atlantic Fishery Management Council, and South Atlantic Fishery Management Council define and develop FMPs that are consistent with national standards for fishery conservation and management along the U.S. eastern seaboard. Fishery management plans for federally-regulated species address the following issues: designation of EFH, identification of habitat areas of particular concern (HAPC), catch quotas, minimum size limits, gear restrictions, permitting restrictions, commercial and recreational seasons, recreational harvest limits, scientific research quotas, commercial trip limits, and overfishing definitions for the appropriate, managed species (*e.g.*, MAFMC 1998a, b, c, d).

Nearshore fisheries operating in state waters (0-3 nautical miles) are under the jurisdiction of the corresponding state and the Atlantic States Marine Fisheries Commission. The ASMFC was established in 1942 by the cooperative efforts of the fifteen Atlantic coast states to assist in managing and conserving their shared coastal fishery resources. The Atlantic Coastal Fisheries Cooperative Management Act of 1993 (Atlantic Coastal Fisheries Act) further provided a mechanism to ensure state compliance with mandated conservation directives in ASMFC-approved FMPs. Non-compliance to recommended conservation provisions of ASMFC FMPs can warrant an imposed moratorium in that state's waters for the particular species in question. The Atlantic Coastal Fisheries Act also awarded the Department of Commerce authority to implement rules in the federal waters of the EEZ to complement the ASFMC's FMPs for those species not federally managed under the Magnuson-Stevens Act.

The following summaries inventory the targeted species of the five categories of the Mid-Atlantic commercial fishery that may be affected by offshore dredging operations. Summaries of the species' life history are provided in Section 2.2.7.3. Jurisdiction of regulated species and corresponding FMPs are provided in Tables 2-16 and 2-17.

Demersal Fishery (Groundfish fishery)

Northeast and Mid-Atlantic demersal fisheries include approximately 35 marine species/stocks, with the majority of these groundfish harvested in New England waters. The dominant harvested species in the Mid-Atlantic groundfish fishery are summer flounder, scup, goosefish, black sea bass, tautog, and winter flounder. Invertebrates of commercial importance include blue crab, rock crab, horseshoe crab, American lobster, surfclam, sea scallop, and conch (whelk). The shellfish will be discussed more in depth in later sections. Main gear used in the harvesting of these species includes otter trawls, gill nets, pots, traps, set lines, and hydraulic dredges. Gear varies for each species. Brief summaries of the life histories of individual species are provided in Section 2.2.7.3 and aid in determining when the species is commercially or recreationally targeted, spawning, migrating, or in the general vicinity of proposed sand borrow sites.

The summer flounder or fluke is an important resource both commercially and recreationally within the Mid-Atlantic Bight. The principal gear used to harvest this species is the otter trawl and the fishery is managed under the Summer Flounder FMP as a unit stock from North Carolina to Maine. Amendment 2
of this FMP sets major regulations describing commercial quotas, minimum fish size, commercial vessel moratorium, and gear restrictions (NEFMC 1998).

Table 2-16. Federally Regulated Species and Their Respective Fishery Management Plans

Species	Jurisdiction	Fishery Management Plan
American Lobster	NEFMC	American Lobster
Atlantic Bluefish	MAMFC	Atlantic Bluefish
Atlantic Butterfish	MAMFC	Atlantic Mackerel, Squid, and Butterfish
Atlantic Herring	NEFMC	Atlantic Herring (FMP Under Development)
Atlantic Mackerel	MAMFC	Atlantic Mackerel, Squid, and Butterfish
Atlantic Sea Scallop	NEFMC	Atlantic Sea Scallop
Black Sea Bass	MAFMC	Summer Flounder, Scup, and Black Sea Bass
Dolphin	SAFMC/GMFMC	Coastal Migratory Pelagics of the Gulf of Mexico and South Atlantic
Illex Squid	MAFMC	Atlantic Mackerel, Squid, and Butterfish
King Mackerel	SAFMC/GMFMC	Coastal Migratory Pelagics of the Gulf of Mexico and South Atlantic
Loligo Squid	MAFMC	Atlantic Mackerel, Squid, and Butterfish
Monkfish	NEFMC	Monkfish (FMP Under Development)
Ocean Pout	NEFMC	Northeast Multispecies
Ocean Quahog	MAFMC	Atlantic Surfclam and Ocean Quahog
Red Drum	SAFMC	Atlantic Coast Red Drum
Red Hake	NEFMC	Northeast Multispecies
Scup	MAFMC	Summer Flounder, Scup, and Black Sea Bass
Silver Hake	NEFMC	Northeast Multispecies
Spanish Mackerel	SAFMC/GMFMC	Coastal Migratory Pelagics of the Gulf of Mexico and South Atlantic
Spiny Dogfish	MAFMC/NEFMC	Dogfish (not finalized)
Summer Flounder	MAFMC	Summer Flounder, Scup, and Black Sea Bass
Surfclam	MAFMC	Atlantic Surfclam and Ocean Quahog
Winter Flounder	NEFMC	Northeast Multispecies
Atlantic Tunas**	HMSMD	Atlantic Tunas, Swordfish, and Sharks Vol. 1
Billfish**	HMSMD	Atlantic Billfish: Amendment 1
Sharks and Swordfish**	HMSMD	Atlantic Tunas, Swordfish, and Sharks Vol. 1

Source: NMFS, 1998
* MAFMC - Mid-Atlantic Fishery Management Council
* NEFMC - New England Fishery Management Council
* SAFMC - South Atlantic Fishery Management Council
* GMFMC - Gulf of Mexico Fishery Management Council
* HMSMD - Highly Migratory Species Management Division, Office of Sustainable Fisheries
** See complete list of individual species managed in following tables.

Table 2-17. Species Regulated by ASMFC or the Appropriate State

Species	Jurisdiction	Fishery Management Plan
Alewife	ASMFC	American Shad and River Herring
American Eel	ASMFC	American Eel (FMP Under Development)
American Shad	ASMFC	American Shad and River Herring
Atlantic Menhaden	ASMFC	Interstate FMP for Atlantic Menhaden
Blue Crab	Individual state	Chesapeake Bay Blue Crab / Individual State
Blueback Herring	ASMFC	American Shad and River Herring
Croaker	ASMFC	Croaker
Horseshoe Crab	ASMFC	Horseshoe Crab
Spot	ASMFC	Spot
Striped Bass	ASMFC	Interstate FMP for Striped Bass / Atl.Striped Bass Conservation Act
Tautog	ASMFC	Tautog
Weakfish	ASMFC	Interstate FMP for Weakfish

Source: NMFS, 1998
* ASMFC - Atlantic States Marine Fisheries Commission

The Red hake or ling reaches its highest abundance in the coastal waters of New Jersey. Principal commercial fishing gear used to harvest this species is the otter trawl. Red hake are included in the New

England Fishery Management Council's Multispecies FMP under the "nonregulated multispecies" category (NEFMC 1998). Party boats or head boats target this species recreationally in northern New Jersey.

The principal gear used to harvest winter flounder is the otter trawl and the fishery is managed under the NEFMC's Multi-species FMP Amendment 11 and the ASMFC FMP for Inshore Stocks of Winter Flounder. Management guidelines from the Multi-species FMP include, designation of EFHs, a moratorium on permits, days-at-sea restrictions, gear restrictions, time/area closures, and minimum size limits (NEFMC 1998).

The tautog fishery is managed under the ASFMC Tautog FMP of 1996 and the primary gear of harvest is the fish pot. It is also important recreationally.

Scup are managed under the MAFMC's Summer Flounder, Scup, and Black Sea Bass FMP Amendment 12. Primary gear is the otter trawl.

Principal commercial fishing gear used to harvest sea bass are fish pots and otter trawls. Black sea bass are managed under Amendment 12 to the Summer Flounder, Scup, and Black Sea Bass FMP developed in October 1998. Management includes the designation of EFH, gear restrictions, a moratorium program, size limitations, commercial quotas, and recreational catch limits.

Principal commercial fishing gears used to harvest the goosefish (monkfish) are anchored gill nets, dredge and bottom trawls. The goosefish is managed under the NEFMC's Monkfish FMP Amendment 1 dealing with the designation of EFH's, gear restrictions, size limits, and commercial catch quotas.

Anadromous / Pelagic Fishery

The anadromous/pelagic fisheries include those fishes that seasonally migrate in a northwestern/southwestern pattern and frequent the upper realms of the water column. Migration is initiated by changes in water temperature, spawning needs, and dietary needs. They are free-swimming and commonly travel in schools in open water and are common inshore during migration associated with spawning. These species include bluefish, American shad, alewife, blueback herring, striped bass, weakfish, and red drum. Of these species, bluefish, weakfish, striped bass, Americam shad, and red drum have significant recreational value as well.

The bluefish is sought both commercially and recreationally. Primary gears used in the commercial harvest of bluefish are gill nets and otter trawls. The bluefish is managed under the MAFMC's and ASMFC's Bluefish FMP Amendment 1. This amendment deals with the designation of EFH's, size limits, gear requirements, commercial quotas with state allocations, and nine-year stock rebuilding schedule.

The American shad is valued not only as an important commercial food fish but is also exploited for its roe. Principal gear used to commercially harvest this species is the gill net and it is currently managed under the ASMFC's coastwide FMP for American shad and river herring. This plan addresses the need for improved habitat, fish stocking, stock transfer, fish passage, and extensive research and tagging programs.

The river herring fishery in the Mid-Atlantic region is predominantly offshore and the gear types used are fish weirs, pound nets, and gill nets (NEFSC 1998c). Recreational fisheries for the river herring are insignificant in comparison to the commercial industry. The two species (alewife and blueback herring) are managed under the ASMFC's coastwide FMP for American shad and river herring which defines the need for cooperative management and restoration efforts between the states, continued research, and fish passage programs. Principal gear for commercial harvest of striped bass includes pound and gill nets, hook and line, seines, and otter trawls; yet recreational landings seem to substantially exceed commercial landings. It is unlawful to commercially fish for striped bass in the state of New Jersey or use any gear type other than hook and line. Striped bass are regulated under an ASMFC interstate FMP for Striped Bass and the Atlantic Striped Bass Conservation Act.

Weakfish are harvested commercially with otter trawls, pound and gill nets, and hook and line. The weakfish is managed under Amendment 3 to the interstate FMP for Weakfish, adopted by ASMFC in 1996. Closure for all fishing of weakfish in the EEZ is currently pending. All states under the jurisdiction of the FMP work with USFNS and NMFS to preserve future stock, prohibit use of certain fishing gear, establish water flow guidelines, and preserve existing weakfish habitat (ASMFC 1996).

The red drum is considered more of a recreational gamefish, but is stringently regulated commercially. Primary gear used to harvest this inshore species commercially is the gill net and limit is heavily restricted as a by-catch fishery with regulated bag limits. Commercial fishing for red drum is prohibited in some southern states. This fishery is managed under the ASMFC interstate FMP for Red Drum. Amendment 1 sets catch quotas, size limits, closure of the EEZ for all types of fishing, and directs the regulation of juvenile escapement rates from the estuary to open waters (Roger Pougliese, SAFMC, pers. comm., Feb., 1999).

Pelagic Fishery

The pelagic fishery industry harvests those species that are found in mid-water to ocean surface of the water column. The commercial gears used are the otter trawl and purse seine. These fish are seasonally migratory and periodically pass through various regions of the Mid-Atlantic Bight. The pelagic species of commercial importance for the middle Atlantic are silver hake, butterfish, menhaden, and Atlantic mackerel. Of these, Atlantic mackerel has the most recreational value. Highly migratory species of commercial and recreational importance are listed in Tables 2-18 and 2-19. These species are in greater concentration outside of the study area in deeper waters.

The silver hake is an important commercial species harvested in the northern areas of the Mid-Atlantic Bight. The principal commercial gear utilized to harvest this species is the otter trawl. This species has little recreational value. Silver hake is regulated under the NEFMC's Amendment 11 of the Multispecies FMP, designating EFHs, gear restrictions, catch quotas, and size limitations.

The butterfish is a commercially harvested baitfish with distribution from Florida to Newfoundland. Primary commercial gear used in the harvest of butterfish is the otter trawl and this fishery is managed under Amendment 8 of the Mid-Atlantic Fishery Council's FMP for Atlantic Mackerel, Squid, and Butterfish. This plan sets catch quotas, size limits, gear restrictions, and designates areas as EFH.

The menhaden is considered to be one of the most important fisheries in total landings along the Mid-Atlantic Bight. The chief commercial gear used in the harvest of menhaden is the purse seine. This fishery is managed under the ASMFC's Interstate FMP for Menhaden.

The Atlantic mackerel is a moderately important commercial and recreational fishery and primary commercial gear used is the otter trawl. It is recreationally targeted by head boats and private vessels that use hook and line. This fishery is managed under Amendment 8 to the MAFMC's FMP for Atlantic herring, squid, and butterfish. This plan identifies EFH's, sets gear restrictions, size limits, annual catch quotas, and management alternatives.

Table 2-18. Migratory Species of Commercial and Recreational Importance (I)

Atlantic Tunas			
		BAYS Tunas	
Atlantic Bluefin	*Thunnus thynnus*		
		Bigeye	*Thunnus obesus*
		Albacore	*Thunnus alaunga*
		Yellowfin	*Thunnus albacares*
		Skipjack	*Katsuwonus pelamis*
Swordfish			
Atlantic Swordfish	*Xiphias gladius*		
Billfish			
Atlantic Blue Marlin	*Makaira nigracans*		
Atlantic White Marlin	*Tetrapturus albidus*		
Atlantic Sailfish	*Istiophorus platypterus*		
Longbill Spearfish	*Tetrapturus pfluegeri*		

Sources: Amendment 1 to the Atlantic Billfish FMP &
Atlantic Tunas, Swordfish, and Sharks FMP, Vol. 1

Catadromous Fishery

The only important catadromous fishery in the Mid-Atlantic Bight is the American eel fishery. Recently, the migration patterns of this species, adult and juvenile, have become important in setting restrictions on juvenile or glass eel harvest. For many years, this fishery only legally existed in the New England region of the United States, but now it has become a major issue in New Jersey.

The adults and elvers are commercially harvested for bait, human consumption, and for the aquaculture industry. Primary gears used in catching adults are otter trawls, seines, drift nets, pound nets, fyke nets, and eel pots (Fahay 1978). Recent gear restrictions may omit the use of some of the previously listed gear. Elvers are harvested by dip net at night in estuarine creeks and canals. A FMP is currently being developed by the ASMFC and should be adopted in 1999 (Bochenek 1998).

Shellfish Fishery

The shellfish fishery is technically a demersal fishery incorporating a variety of gears to harvest marketable bivalves, gastropods, and crustaceans. Commercial gear used includes traps, fish pots, hydraulic dredges,

Table 2-19. Migratory Species of Commercial and Recreational Importance (II)

Prohibited Species *			
Sand Tiger	*Odontaspis taurus*	Narrowtooth	*Carcharhinus brachyurus*
Bigeye Sand Tiger	*Odontaspis noronhai*	Caribbean Sharpnose	*Rhizoprionodon porosus*
Whale	*Rhincodon typus*	**Smalltail**	***Carcharhinus porosus***
Basking	*Cetorhinus maximus*	Atlantic Angel	*Squatina dumerili*
White	*Carcharodon carcharias*	Longfin Mako	*Isurus paucus*
Dusky	*Carcharhinus obscurus*	Bigeye Thresher	*Alopias superciliousus*
Bignose**	***Carcharhinus altimus***	Sevengill	*Heptranchias perlo*
Galapagos	***Carcharhinus galapagensis***	Sixgill	*Hexanchus griseus*
Night	*Carcharhinus signatus*	Bigeye Sixgill	*Hexanchus vitulus*
Caribbean Reef	***Carcharhinus perez***		
	Non-Prohibited Species by Group***		
Large Coastal Sharks			
Ridgeback Species		**Non-Ridgeback Species**	
Sandbar	*Carcharhinus plumbeus*	Blacktip	*Carcharhinus limbatus*
Silky	*Carcharhinus falciformis*	**Spinner**	***Carcharhinus brevipinna***
Tiger	*Galeocerdo cuvieri*	Bull	*Carcharhinus leucas*
		Lemon	*Negaprion brevirostris*
		Nurse	*Ginglymostoma cirratum*
		Scalloped Hammerhead	*Sphyrna lewini*
		Great Hammerhead	***Sphyrna mokarran***
		Smooth Hammerhead	*Sphyrna zygaena*
Small Coastal Sharks			
Atlantic Sharpnose	*Rhizoprionodon terraenovae*	**Blacknose**	*Carcharhinus acronotus*
Finetooth	*Carcharhinus isodon*	Bonnethead	*Sphyrna tiburo*
Pelagic Sharks			
Shortfin Mako	*Isurus oxyrinchus*	Oceanic Whitetip	*Carcharhinus longimanus*
Porbeagle	*Lamna nasus*	Blue	*Prionace glauca*
Thresher	*Alopias vulpinus*		

Source: Final Fisheries Management Plan for Atlantic Tunas, Swordfish, and Shark: Vol.1 (1999)

* These sharks are prohibited for harvest and capture for all recreational and commercial fisheries.

** Species in bold type are managed by the HMS Management Division but inhabitat areas outside the study area.

******* Sharks in the Deepwater and Other Sharks category of non-prohibited sharks have been excluded from the table since they inhabitat deeper waters outside the study area. These species include catsharks, sawsharks, smoothhound, and dogfish. The spiny dogfish is managed by the NEFMC and the MAFMC. A list of all pertinent species within this category can be found in the HMS FMP for Atlantic Tunas, Swordfish, and Sharks: Volume 1(April, 1999 ed.).

rakes, and scallop dredges. Since these invertebrates inhabit the benthos or live within the substrate during their adult life stage, a firm understanding of habitat location, preferred sediment type, and harvest season is necessary in the determination of viable sand resource deposits for mining. Because majorities of shellfish are sessile, they characterize the habitat through population abundance and indicate environmental stresses placed upon their inhabited regions of the benthos. Sediment type is critical to their survival. The following invertebrates prefer sandy substrate and rely on this sediment for food sources, protection from predation, and life stage habitat: surfclam, ocean quahog, sea scallop, rock crab, horseshoe crab, and whelk. American lobster prefer rocky, structure related bottom but can inhabit other types of sediment. The blue crab also inhabits a variety of habitats through inshore. The possibility of disrupting such a vast marine resource must be considered.

The Atlantic surfclam is commercially of importance off New Jersey and the Delmarva Peninsula. These bivalves are harvested commercially year round with the principal gear being the hydraulic clam dredge. This fishery is managed under the MAFMC FMP to the Atlantic Surfclam and Ocean Quahog, Amendment 12. The plan designates EFH, catch limits and permit requirements, and defines overfishing for surfclams.

The ocean quahog is a highly valued commercial commodity. Primary gears used for commercial harvest are the dredge and the bottom trawl. The hard-shell clam fishery is managed under the MAFMC's Atlantic Surfclam and Ocean Quahog FMP. Amendment 12 designates EFHs and alternatives to management, habitat requirements, and regulatory actions.

The sea scallop is generally distributed in the middle Atlantic in water depths between 22 and 110 fathoms with highest commercial concentrations in depths from 22 to 55 fathoms. Commercial fishing gears used are the scallop dredge and the otter trawl with primary fishing grounds located offshore Mid-Atlantic Bight. Commercial fishing for scallops is conducted year round when practicable. This shellfish fishery is managed under the NEFMC FMP for the Atlantic Sea Scallop. Amendment 9 specifies essential fish habitat, references gear restrictions, area closures, days-at-sea programs, and trip limits.

The rock crab is one of the more common, shallow water crabs along the northeastern portion of the Atlantic coast. Commercially, this is considered a by-catch fishery since these crustaceans are usually caught in lobster pots and bottom trawls along with a more marketable species. It is marketed for its meat, claw, and as bait. Currently, there is not a management plan for this species.

The horseshoe crab is commercially harvested for pharmaceutical purposes and for bait used in the eel, conch, and catfish fisheries, but have ecological significance when spawning since their eggs provide a major food source for migrating shorebirds. Commercial harvest is primarily by hand collection with some harvesting offshore by dredge. The majority of the Mid-Atlantic States has banned all trawls for the purpose of harvest and has placed stringent regulations on catch limits. This fishery is managed under the ASMFC's Interstate FMP for the Horseshoe Crab with individual state fishery restrictions.

Several species of whelk are harvested commercially in the entitled Conch Fishery. Of these, two species are commercially important in the Mid-Atlantic Bight. The knobbed whelk and the channeled whelk are sympatrically distributed along the eastern seaboard from Cape Cod to northern Florida. These two species are harvested year round and the principal gears used are the conch pot, otter trawl, and dredge. The whelk or conch is commercially targeted with pots and dredges, but it is also a bycatch for demersal fishery related gear. Currently, there is no federal FMP for the whelk.

The American lobster has been harvested commercially since the 1700's and continues to be an important fishery in the northern region of the Mid-Atlantic Bight. The principal gear used to commercially harvest this crustacean is the trap or pot. This fishery is managed under the ASMFC's Interstate FMP for American Lobster, Amendment 3. This plan includes landing size requirements, gear modifications, gear size limitations, and designated fishing areas.

The blue crab is harvested primarily in the inshore waters and brackish estuaries from Massachusetts to South America and is abundantly harvested along the coastal areas of the Mid-Atlantic states. The fishery is important and economically invaluable commercially and recreationally. Primary commercial gear is the

crab pot. This species is managed by individual state and under the Chesapeake Bay Blue Crab FMP to limit gear, prevent over-explotation, and increase research.

2.2.8.1.2 Recreational Fishery

The recreational fishery is comprised primarily of private boats. Head boats, also referred to as party boats, along with charters constitute another aspect of the recreational fishery. This type of fishery is also considered to be commercial even though it is comprised of recreational anglers utilizing primarily hook and line. Head boats are larger vessels, in comparison to the smaller charters, and take a sizeable number of patrons to specific fishing grounds nearshore and offshore to harvest fish by hook and line. Species targeted include; bluefish, striped bass, weakfish, black sea bass, tautog, summer flounder, Atlantic mackerel, red drum and red hake. Other methods of recreational fishing include surf fishing, cast netting, dip netting, and recreational potting. Red drum, bluefish, weakfish, summer flounder, and striped bass are highly sought gamefish from the shore and back bay areas. The majority of these fishing methods utilized in nearshore waters are closely regulated by the state. The states determine size limits, fishing season, and bag limits from the ASFMC FMPs and with recommendations from NMFS and the appropriate fishery councils.

2.2.8.1.3 Catch Landings Data of Commercially and Recreationally Important Fish and Shellfish of the Middle Atlantic Region

To understand the magnitude and value of fishing along the Mid-Atlantic coast of the United States, it is necessary to know who targets which species, location and season where the fish are harvested, the size of the catch, and the exvessel revenue generated. Targeted species and catch landings vary from state to state based on that fishery's economic importance, seasonality, and availability (Tables 2-20 through 2-23). Table 2-24 summarizes the commercial and recreational catch statistics for the four states within the study area from 1990-1997.

Commercial Fishing

The Mid-Atlantic region contains numerous fishing ports in New Jersey, Delaware, Maryland, and Virginia. Combined commercial landings of all Mid-Atlantic ports for 1997 contributed an average of 46% of the total catch landings and 23% of the total value along the entire east coast (Maine to Florida). The catch volume and exvessel value of the commercial fish and shellfish in this region's ports has fluctuated over the past 7 years, from 1,032 million lbs. and $258 million dollars in 1990 to a high of 1,039 million lbs. with $283 million in 1995 (Table 2-24). Since 1995, there has been a gradual decrease in pounds harvested, but a steady increase in total revenue generated. In 1997, for example, total landings were only 845 million lbs. (a decrease of 80 million lbs. from 1996), but the catch was valued at $270 million dollars, whereas 1996 total revenue was only $262 million. There was a substantial increase observed in pounds harvested from 1994 to 1995 (Table 2-24).

Current Status of Commercial Fisheries for the Mid-Atlantic Bight

Table 2-23 depicts the current status of each commercial fishing industry for the Mid-Atlantic Bight. Data were compiled from NMFS Fisheries Statistics and Economics Division and the NMFS Report to Congress on the Status of Fisheries of the United States published in September of 1998. Status determination was based on the criteria by the accepted overfishing definition specified in the respective FMP, fishing mortality rates, or stock levels as required by the Magnuson-Stevens Fishery Act and the SFA of 1996. The status report includes only those species currently included in a FMP within or not within a management unit. Species solely in state waters are not included. Each commercial fishery has been categorized in table

Table 2-20.
Annual Landings of Selected Commercially Important Marine Species for New Jersey from 1990-1997
(Landings are in 1000 lbs)

Species	1990	1991	1992	1993	1994	1995	1996	1997	Total Landing
Goosefish	1,064	2,045	3,118	3,082	2,445	4,202	5,138	6,458	27,552
Bluefish	2,171	2,448	2,198	2,191	1,892	848	1,612	1,233	14,593
Butterfish	582	567	925	1,336	454	268	444	571	5,147
Flounder, Winter	222	258	284	244	310	581	147	126	2,172
Flounder, Summer	1,458	2,341	2,871	2,463	2,356	2,319	2,369	1,321	17,498
Hake, Red	732	604	429	516	499	412	134	235	3,561
Mackerel, Atlantic	5,629	18,549	8,916	2,764	5,944	4,754	18,007	9,566	74,129
Menhaden, Atl.	9,041	16,597	27,471	28,297	38,350	36,580	35,517	38,119	229,972
Scup or Porgies	2,215	4,320	3,252	4,016	3,208	2,214	2,412	1,273	22,910
Black Sea bass	990	1,034	1,245	1,381	957	797	1,222	705	8,331
Weakfish	968	1,174	941	834	695	867	822	1,036	7,337
Shad, American buck	114	44	57	45	24	31	29	38	382
Shad, American roe	451	275	275	291	187	229	172	202	2,082
Shad, American	47	134	35	26	50	33	12	19	356
Mackerel, Spanish	28	77	52	23	20	2	41	12	255
Tautog	99	93	116	153	163	116	89	50	879
Hake, Silver	8,627	4,355	2,079	2,422	2,678	2,731	1,798	2,174	26,864
Crab, Blue	4,523	4,922	6,157	7,520	5,156	6,739	3,599	4,291	42,907
Crab, Blue Peeler	317	50	372	221	448	958	224	272	2,862
Crab, Rock	349	13	0	0	18	16	18	59	473
Horseshoe Crab	289	351	305	699	917	1,441	1,809	1,101	6,912
Lobster, American	2,199	1,673	1,213	906	581	606	640	858	8,676
Clam, Atlantic Surf	44,774	45,955	52,892	47,978	48,572	46,329	48,741	45,603	380,844
Scallop, Sea	4,615	4,825	3,313	2,280	2,766	2,560	2,355	1,965	24,679
Conch (whelk)	51	82	161	275	173	137	301	299	1,479
Total	91,555	112,786	118,677	109,963	118,863	115,770	127,652	117,586	912,852

- Landings are reported in pounds of round (live) weight
- Bivalve mollusks are reported as meat weights (excludes shell weight)

Source: NMFS, Fisheries Statistic Division 1999

Table 2-21
Annual Landings of Selected Commercially Important Marine Species for Delaware from 1990-1997
(Landings are in 1000 lbs)

Species	1990	1991	1992	1993	1994	1995	1996	1997	Total Landing
Goosefish						242		0	242
Bluefish	144	338	93	30	35	36		29	705
Butterfish	2	6	1	2	1	1		1	14
Flounder, Winter				8					
Flounder, Summer	2	4	12		4	4		5	31
Hake, Red	1	1	2	5	3	1		2*	13
Mackerel, Atlantic	6	1	0	0		1		1	9
Menhaden, Atl.	141	280	106	164	79	101	101	56	1,028
Scup or Porgies						3		0	3
Black Sea bass					70			152	222
Weakfish	613	497	362	195	262	281		559	2,769
Shad, American	494	471	284	317	224	205		173	2,168
Tautog	1	1	0	0	0	1		1	4
Crab, Blue	7,007	6,765	4,513	6,368	6,185	7,507	3,687	5,355	47,387
Crab, Blue Peeler and Soft	196	24	442	283	305	518	220	97	2,085
Horseshoe Crab	169			118	237	463	188	2,109	3,284
Lobster, American	68	55	21	24	8			0	176
Conch (whelk)				153	190	93	92	111	639
Total	8,844	8,443	5,836	7,667	7,603	9,457	4,288	8,649	60,779

* Aggregate round weight of Atlantic, white, and red hake
** Landings are reported in pounds of round (live) weight
*** Bivalve mollusks are reported as meat weights (excludes shell weight)
Source: NMFS, Fisheries Statistic Division 1999

Table 2-22.
Annual Landings of Selected Commercially Important Marine Species for Maryland from 1990-1997
(Landings are in 1000 lbs)

Species	1990	1991	1992	1993	1994	1995	1996	1997	Total Landing
Goosefish	23	44	36	20	168	414		714	1,419
Bluefish	285	233	206	134	165	108			1,131
Butterfish	130	62	67	15	18	15	0	12	319
Flounder, Winter	0	0	2	2	3	5	1	2	15
Flounder, Summer	139	234	319	274	180	175	215	180	1,716
Hake, Red	26	11	11	11	8	0		11	78
Mackerel, Atlantic	124	117	161	13	2				417
Menhaden, Atl.	2,634	3,540	2,295	3,086	3,512			4,899	19,966
Scup or Porgies	9	34	37	23	15	2	42	2	164
Black Sea bass	343	481	468	362	220	303	546	513	3,236
Weakfish	662	328	385	182	141	69	133	193	2,093
Shad, American buck	154	84	91	29	3	6	39	5	411
Shad, American roe	229	202	162	61	14	10	83	14	775
Shad, American	32	4	11	9	5			147	208
Mackerel, Spanish	43	63	38	9	3	3		3	162
Tautog	4	3	4	1	2	4	4	8	30
Hake, Silver	22	15	2	14	3	4		2	62
Crab, Blue	50,786	49,756	29,174	59,764	44,938	42,524	37,175	43,979	358,096
Crab, Blue Peeler	18	20	31	37	25	35	0	39	205
Crab, Rock							0	2	2
Horseshoe Crab					232		1,442	1,723	3,397
Lobster, American					8	3	29	34	74
Clam, Atlantic Surf	6,187	6,709	5,758	6,452	6,904				32,010
Scallop, Sea	26	128	69	7	2	4	10	1	247
Conch (whelk)					428	166		339	933
Total	61,876	62,068	39,327	70,505	56,999	43,850	39,719	52,822	427,166

* Landings are reported in pounds of round (live) weight
* Bivalve mollusks are reported as meat weights (excludes shell weight)

Source: NMFS, Fisheries Statistic Division 1999

Table 2-23.
Annual Landings of Selected Commercially Important Marine Species for Virginia from 1990-1997
(Landings are in 1000 lbs)

Species	1990	1991	1992	1993	1994	1995	1996	1997	Total Landing
Goosefish	1,219	1,580	2,361	1,956	1,147	2,282	2,051	2,306	14,902
Bluefish	1,083	824	593	649	628	538	616	739	5,670
Butterfish	102	74	92	325	219	172	184	154	1,322
Flounder, Winter	9	11	11	21	5	9	1	1	68
Flounder, Summer	2,145	3,713	5,172	3,134	3,119	3,312	2,304	2,370	25,269
Hake, Red	13	7	2	4	6	1	2	2	37
Mackerel, Atlantic	1,756	1,442	924	672	48				4,842
Menhaden, Atl.	5,692	5,876	5,220	7,180	5,665			497,161	526,794
Scup or Porgies	165	123	161	167	203	44	155	4	1,022
Black Sea bass	886	499	580	763	390	363	790	486	4,757
Weakfish	1,173	1,060	550	1,087	1,294	1,485	1,587	1,558	9,794
Shad, American buck	28	104	38	11	4	10	17	18	230
Shad, American roe	77	209	157	41	31	26	50	53	644
Shad, American	350	118	284	501	342	114	171	287	2,167
Mackerel, Spanish	478	447	271	335	377	169	284	165	2,526
Tautog	5	5	4	5	11	30	26	25	111
Hake, Silver	57	30	6	12	10	8	10	5	138
Crab, Blue	45,315	42,103	23,309	51,355	34,020	30,800	32,518	36,998	296,418
Crab, Blue Peeler	875	771	291	1,480	1,258	1,608	1,634	1,998	9,915
Crab, Rock									
Horseshoe Crab	45	25	6	4	15	21	86	53	255
Lobster, American								2	2
Clam, Atlantic Surf	5,604								5,604
Scallop, Sea	8,759	8,773	6,692	3,231	6,261	5,766	5,035	2,733	47,250
Conch (whelk)	279	558	135	1,794	3,527	1,220	1,356	502	9,371
Total	76,115	68,352	46,859	74,727	58,580	47,978	48,877	547,620	969,108

* Landings are reported in pounds of round (live) weight
* Bivalve mollusks are reported as meat weights (excludes shell weight)

Source: NMFS, Fisheries Statistic Division 1999

**Table 2-24.
Commercial Landings and Exvessel Revenue of All Marine Species Combined for the Mid-Atlantic States of NJ, DE, MD, and VA
1990-1997**

Year	Metric Tons (1000s tons)	Pounds (millions of lbs.)	Revenue (millions of $$)
1990	468	1,032	258
1991	432	951	243
1992	407	899	228
1993	464	1,022	271
1994	373	820	267
1995	471	1,039	283
1996	419	925	262
1997	384	845	270
Totals	3,418	7,533	2,082

Source: NMFS, Fisheries Statistics and Economics Div., 1999

Table 2-25. Current Status of Mid-Atlantic Bight Fisheries*

Stock	Jurisdiction	Overfished?	Approaching Overfishing?	Basis of Over-fishing definition
American Lobster	NEFMC	Yes	N/A	FMR
Atlantic Herring	NEFMC	No	No	FMR
Atlantic Mackerel	MAFMC	No	No	FMR
Atlantic Menhaden	ASFMC	No	Unknown	SL
Atlantic Sea Scallop	NEFMC	Yes	N/A	FMR
Black Sea Bass	MAFMC	Yes	N/A	FMR
Bluefish	MAFMC	Yes	N/A	FMR
Butterfish	MAFMC	No	No	FMR/SL
Monkfish	NEFMC/ MAFMC	Yes	N/A	SL
Ocean Quahog	MAFMC	No	No	FMR
Red Drum	SAFMC	Yes	N/A	FMR
Red Hake	NEFMC	Yes	N/A	SL
Scup	MAFMC	Yes	N/A	FMR
Silver Hake	NEFMC	Yes	N/A	SL
Spanish Mackerel	SAFMC/ GMFMC	No	No	FMR
Striped Bass	ASFMC	No	Unknown	SL
Summer Flounder	MAFMC	Yes	N/A	FMR
Surfclam	MAFMC	No	No	FMR
Weakfish	ASMFC	Yes	N/A	SL
Winter Flounder	NEFMC	Yes	N/A	FMR

*Additional recent data does exist, but cannot be cited or used until the draft of *Our Living Oceans*, June 1999, is published.
FMR = fishing mortality rate
SL = stock level
Source: NMFS 1998c.

form for clarity purposes and reflects population presence within the EEZ (waters seaward from 3 to 200 nautical miles offshore the United States). Of the 20 fisheries listed, 60% of them are overfished and 40% are considered stable and not approaching their respective overfishing definition. It is unknown if Atlantic menhaden or striped bass are approaching their overfishing definition.

Jurisdiction of a specific fishery in the Mid-Atlantic Bight rests with either the NEFMC, MAFMC, SAMFC, or the ASMFC. The overfishing definition for each fishery varies and is based on fishing mortality rate (FMR) or stock level (SL). FMR is defined as the rate of removal of fish from a population by fishing. It can be reported annually or instantaneously. Instantaneous mortality is defined as the percentage of fish dying at any one point in time. SL is the size of the stock, determined through scientific research, at a certain point in time.

Recreational Fishery

Recreational fishing is an extremely popular activity in the Mid-Atlantic Bight conducted by coastal, noncoastal, and out-of-state anglers. The majority of sport fishermen harvest their target species aboard private boats, rental boats, party or head boats, and charter boats. Land based angling locations include jetties, piers, docks, bulkheads, bridges, and beaches. Some of the primary fishing techniques used are trolling, drifting, bottom fishing, fly fishing, and surf fishing. Revenue is generated from the sale of bait, tackle, lodging, boat rentals, slip rentals, boat repair, fuel, boat charters, etc. Recreational fishing is economically important to the coastal community because it not only provides profit; it provides a livelihood. Catch landings are notable and range from thousands of pounds to millions of pounds harvested annually. In some states, the recreational catch exceeds the commercial catch landings (Table 2-26).

Even though the total number of recreational fishing trips in the Mid-Atlantic Bight has increased since 1995, the number of anglers has fluctuated. Virginia is the only state that shows an increase in the total number of recreational anglers for 1997 (Table 2-27).

Out of state anglers and coastal residents comprise the vast majority of the population that utilizes the recreational fishery. The largest numbers of participants for the Mid-Atlantic region are coastal residents and they represent over 50% of the total anglers annually. Delaware is just the opposite from the other three states in the region. Delaware's out of state anglers represent over 60% of the total anglers annually. Non-coastal residents for all states are representative of the minority of total recreational fisherman.

2.2.8.2 Artificial Reefs

An artificial reef is classified as a man-made, marine habitat created in the navigable waters of the United States or in waters overlying the OCS and is composed of various sinkable, natural or recycled materials ranging from large vessels to concrete-filled tires. Other materials include rock rubble, decommissioned military vehicles, concrete debris, and culverts. These sites are constructed to create and enhance bottom structure for marine life habitat and to provide new, accessible areas for improved recreational fishing. Defined as fish havens on some NOAA nautical charts, artificial reef construction and planning has been proceeding at a steady rate along the Atlantic Coast for over a decade. Soon after the deployment of such sites, adult fish species appear among the reef structures and shellfish communities develop, clearly demonstrating the artificial reef's effectiveness to create suitable habitat. Research continues to determine the validity of these sites as productive, stock habitats and possible spawning areas.

The four states within the study area have non-profit, artificial reef programs. These programs are permitted by each individual state or, in the case of Maryland's reef program, by the nearest municipality. Collectively, there are 45 artificial reef sites in this region with each ocean reef site varying in size, depth, and of course location, thus attracting a variety of demersal and migratory marine species. These site numbers continue to grow as more area reef sites are planned for future deployment. Some of the species found on reef sites include black sea bass, tautog, scup, cunner, monkfish, ocean pout, and red hake. Artificial reefs support a large recreational diving and fishing industry and continue to grow in order to meet the demand for more fish habitat and diveable wrecks. Commercial use is confined to potting, trapping and gill netting for black sea bass, monkfish, tautog, and lobster. Commercial and recreational use of these areas varies from state to state, as do restrictions that regulate individual species.

New Jersey

New Jersey's Artificial Reef program was designed to construct hard-substrate habitat in the ocean for certain marine species and provide new recreational areas for angling and diving. The Reef program was established in 1984 and current data indicates a total of 14 reef sites, within 2 to 25 nautical miles from shore, containing over 1,200 patch reefs (Figure 2-84 and 2-85). A patch reef is ½ to five-acre underwater area comprised of vessels, barges, tanks, tire units, rubble, and other types of recycled material that forms the larger reef sites.

Table 2-26.
Annual Recreational Catch Landings of Specific Species by State for the Mid-Atlantic Bight, 1990-1997

(weights are in 1000 lbs. Increments)

Species	1990	1991	1992	1993	1994	1995	1996	1997	Total
New Jersey									
Bluefish	3115	3278	2404	830	1053	1677	2378	1718	16453
Red hake	738	554	455	190	115	126	55	415	2648
Weakfish	10	24	11	0	36	40	29	131	281
Flounder, Summer	162	212	95	121	239	133	541	905	2408
Flounder, Winter	6	0	1			64			71
Sea Bass, Black	819	975	680	1586	1423	2861	4162	2623	15129
Mackerel, Atlantic	882	669	3	0.2	62	843	286	569	3314.2
Tautog	369	609	786	351	82	436	575	186	3394
Bass, Striped	9	51	0	86	0	102	111	53	412
Delaware									
	1990	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**Total**
Bluefish	44	245	33	46	18	3	100	11	500
Red hake	34	3	1	6	1	0		1	46
Weakfish	28	6	2	1	0	6	34	25	102
Flounder, Summer	13	3	1	1	1	3	15	37	74
Sea Bass, Black	43	144	60	115	18	125	33	57	595
Mackerel, Atlantic	26	47	21		4	37	8	57	200
Tautog	2	6	18	36	9	9	25	86	191
Bass, Striped				2	1	1	11	28	43
Maryland									
	1990	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**Total**
Bluefish	393	226	122	222	14	256	65	503	1801
Red hake	26	25	3		131	49	1	3	238
Weakfish	51	24	3	32	110	1	4	15	240
Flounder, Summer	0	3	2	5	10	16	4	16	56
Sea Bass, Black	270	370	462	470	197	1773	321	367	4230
Mackerel, Atlantic	485	175	44	0	6	7	123	62	902
Tautog	2	17	17	36	30	3	1	25	131
Bass, Striped					0	8			8

Source, NMFS, Fisheries Statistics Division 1999.

* Weight based on NMFS catch type A (fish landed whole) combined with type B1 (fish not available in whole form for identification, includes filletted, cut bait, etc.)

Table 2-26 (Continued).
Annual Recreational Catch Landings of Specific Species by State for the Mid-Atlantic Bight, 1990-1997
(weights are in 1000 lbs. Increments)

Virginia									
	1990	1991	1992	1993	1994	1995	1996	1997	Total
Bluefish	362	215	196	45	32	135	3	214	1202
Weakfish	26	84	9	3	7	6	15	14	164
Drum, Red		5	3		0	0		0	8
Flounder, Summer	47	14	29	11	21	20	71	52	265
Sea Bass, Black	727	1392	401	259	832	486	530	604	5231
Mackerel, Atlantic	35	47	25			2	4	54	167
Mackerel, Spanish	49	23	25	8	16	5	0	7	133
Tautog	52	347	71	214	511	196	294	131	1816
Bass, Striped		0		18	0	69	282	465	834

Source, NMFS, Fisheries Statistics Division 1999.
* Weight based on NMFS catch type A (fish landed whole) combined with type B1 (fish not available in whole form for identification, includes filletted, cut bait, etc.)

Table 2-27.
Estimated Number (in thousands) by State of Recreational Anglers Fishing off the Coast of the Mid-Atlantic Region

		New Jersey					Delaware		
Year	Coastal Residents	Non-Coastal Residents	Out of State Residents	Total	Year	Coastal Residents	Non-Coastal Residents	Out of State Residents	Total
1990	495	25	366	886	1990	81	0	160	241
1991	596	19	417	1032	1991	72	0	109	181
1992	408	14	336	758	1992	80	0	115	195
1993	583	9	433	1025	1993	90	0	159	249
1994	616	21	477	1114	1994	79	0	122	201
1995	482	13	432	927	1995	108	0	185	293
1996	521	22	455	998	1996	94	0	142	236
1997	468	21	384	873	1997	86	0	137	223
		Maryland					Virginia		
1990	338	14	270	622	1990	254	50	108	412
1991	377	28	239	644	1991	365	86	266	717
1992	321	11	202	534	1992	243	41	96	380
1993	540	32	268	840	1993	294	29	131	454
1994	489	43	279	811	1994	311	53	202	566
1995	478	32	360	870	1995	246	46	263	555
1996	508	32	353	893	1996	240	37	230	507
1997	426	29	263	718	1997	381	66	286	733

Source: NMFS 1999.

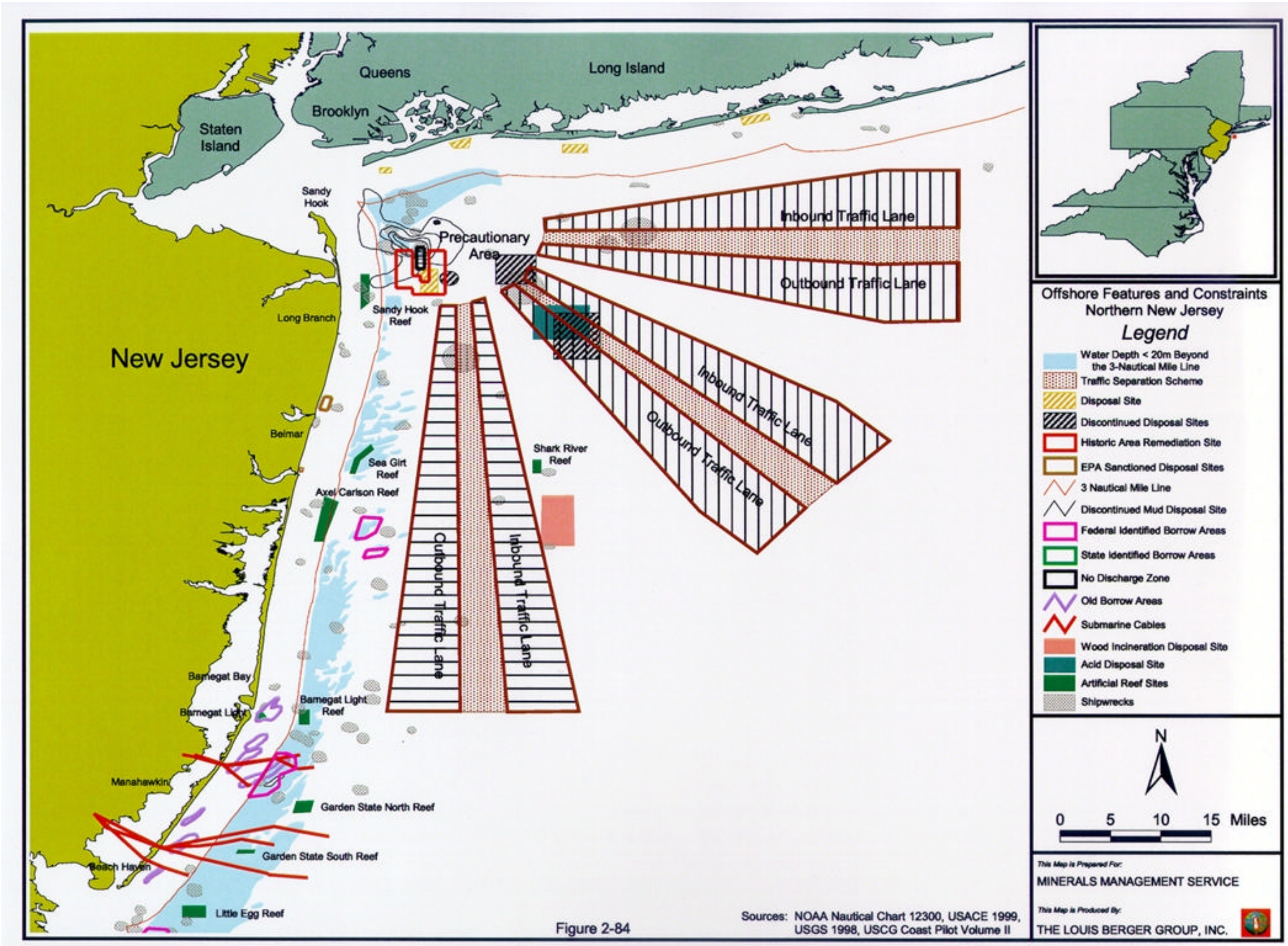


Figure 2-84. North Jersey Reefs Sites, Sand Sites, Shipwrecks, and Shoals (I)

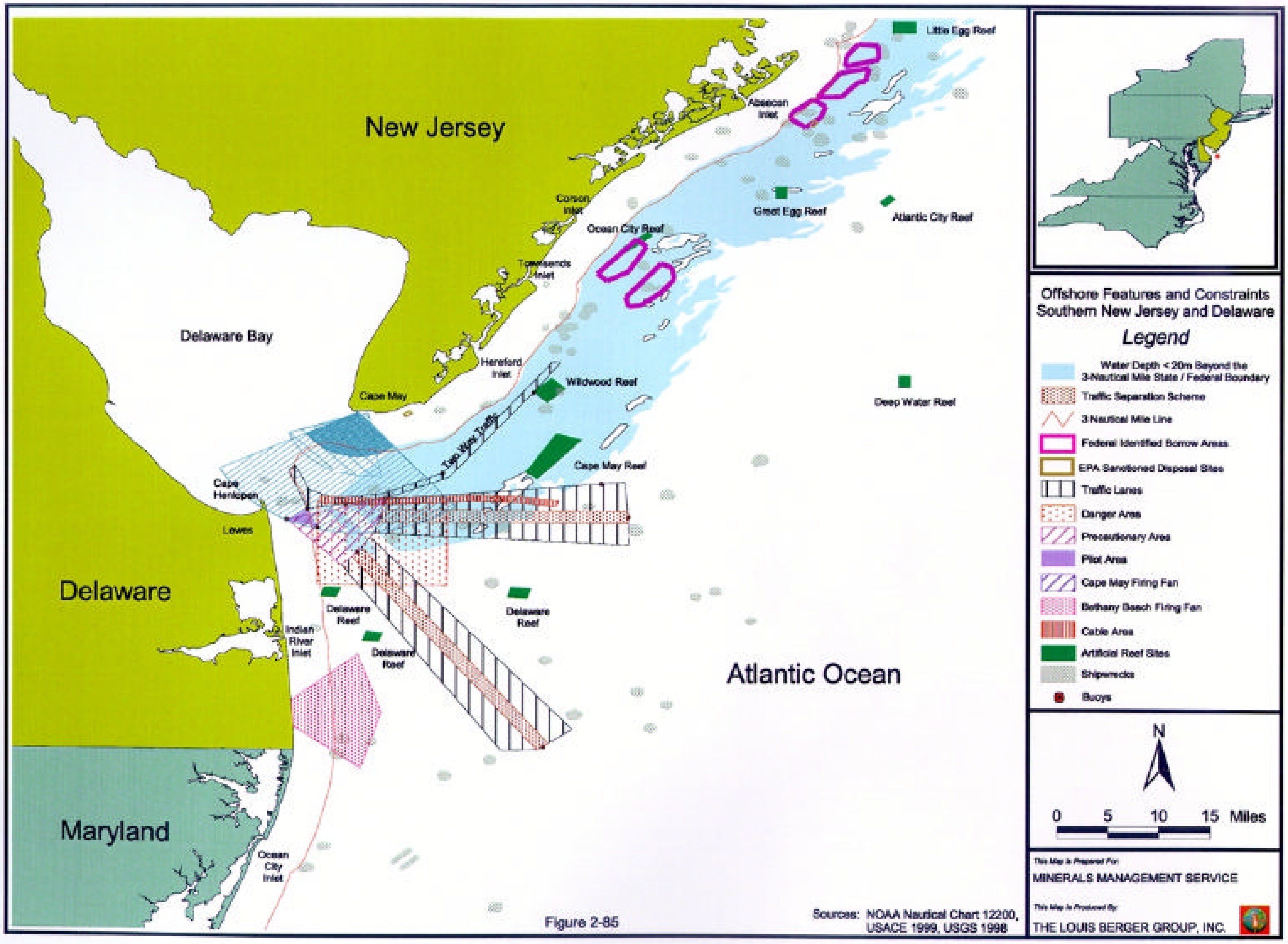


Figure 2-85. South Jersey/Delaware Reefs Sites, Sand Sites, Shipwrecks, and Shoals (II)

Of the 14 reef sites, 12 either border, or are located beyond the three-mile limit of state waters. The average range in depth is between 50-80 feet and the sites cover a collective area of 99 million square yards, with only 1.2 million square yards covered with reef material. Distance from nearest port for the 12 offshore, ocean sites ranges from 3.1 nautical miles to 25 nautical miles. All support a benthic community and attract a variety of demersal and pelagic fish species. These species include tautog, black sea bass, scup, red hake, ocean pout, and invertebrate species like American lobster, rock crab, moon snail, and mussels.

Delaware

Delaware has 11 permitted artificial reef sites along its coastline and the Delaware Bay area (Figure 2-85). Reef construction began in 1995 and has developed the once featureless, nearshore ocean bottom into a structure orientated marine community. Some of the commercially and recreationally important species that inhabit these areas are tautog, black sea bass, scup, spadefish, and triggerfish. These sites vary in composition from concrete culvert pipe and other concrete material to ballasted tires and donated vessels.

Of these 11 artificial reef sites, 3 sites are considered offshore and in close proximity to potential aggregate resources. They encompass a total area of 2.62 nautical miles and are composed of military vehicles, tires, and concrete culverts. The depths of these offshore reef sites range from 52 to 88 feet (mean low water) with distances from Indian River Inlet ranging from 4.5 nautical miles to 16.5 nautical miles. All three sites support blue mussel communities and attract both demersal and pelagic fishes (Delaware Division of Fish and Game 1999). Natural shoal areas, like Hen and Chicken Shoal, have been documented as possible nursery sites for sand tiger sharks. Sand tiger sharks are currently being identified as candidates for possible addition to the List of Endangered and Threatened Species. This area could be designated closed in the near future (J. Tinsman, Delaware Artificial Reef Program, pers. comm., Feb. 1999).

Maryland

Maryland has a total of 6 artificial reef sites, 5 of which are active (Figure 2-86). The inactive site, Little Gull Reef, is approximately 1.5 to 2 nautical miles offshore Assateague Island and is believed to provide shoreline protection for the Assateague Island beaches. Its permit as a reef site expired before the early 1980's and has not been re-permitted since (D. Myatt, pers. comm., Feb. 1999). The other 5 sites range in location from 1000 yards to 22 nautical miles from Maryland's coast and their current permits are retained by the town of Ocean City, Maryland, under the stipulation that municipal revenues would not be used for reef program funding. Even though, the Ocean City Reef Foundation began as a state program in the late 1960s; it is currently under the administrative management of the Ocean City Recreation and Parks Department of Ocean City, Maryland.

Currently, discussion exists on creating a fish refuge to protect certain wreck species like the black sea bass. One site consideration is the Great Eastern Reef. It has excellent populations of black sea bass, scup, tautog, hake, cod, and pollock. The other proposed site is off the Isle of Wight Shoal. It is relatively close to shore but the bottom is composed of old wrecks and debris that make conventional fishing methods difficult. Great Gull Reef is currently being mined for sand to aid in the replenishment of Assateague Island's beach face (D. Myatt, pers. comm., Feb. 1999). Bass Grounds Reef has not been updated on nautical charts and contains six new wrecks.

Virginia

Virginia's artificial reef program, managed by the Virginia Marine Resources Commission (VMRC), was designed to transform the state's coastal waters and the waters of the Chesapeake Bay into hard substrate habitats. The substrate of these waters was composed mostly of soft mud or shifting sands which left a vast

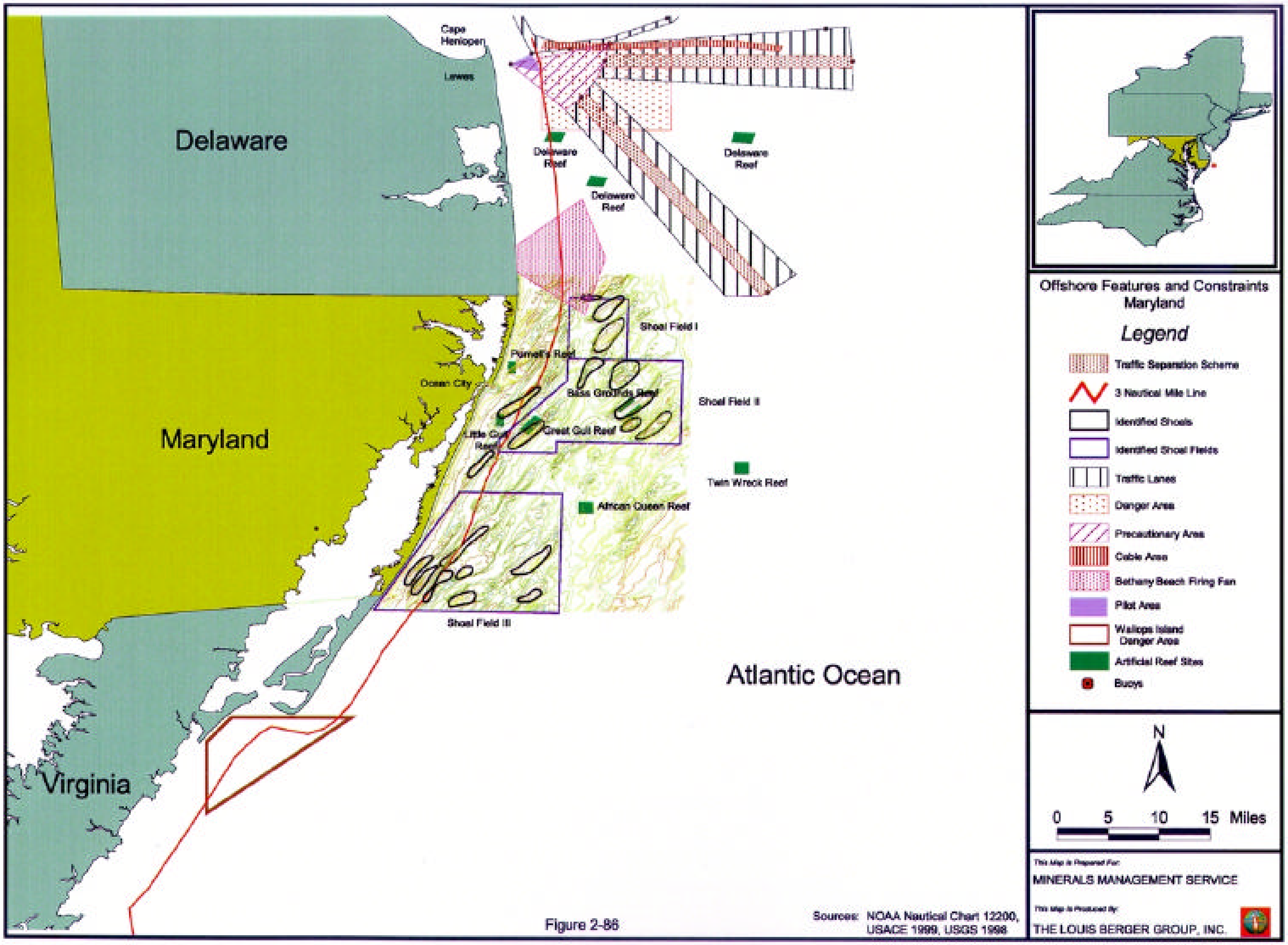


Figure 2-86. MD Reef Sites and Shoal Regions

area devoid of encrusting organisms. Historically, the reef program began in the 1950's by recreational anglers attempting to create fish habitat, but it wasn't until the late 1970's that the Marine Resources Commission became officially involved. Since then, Virginia has established 14 reef sites total, with five of those located offshore from three nautical miles to 16.5 nautical miles. Two reef sites were reactivated during the summer of 1998, the Blackfish Bank Reef offshore and the inshore Middle Ground Reef and more sites are in the planning stages for the future. Both the Blackfish Bank Reef and Middle Ground Reef are included in the total number of current reef sites. Permitted reef site locations are designated by yellow buoys which may be stationed near published Loran coordinates, the center of the reef site, or on the perimeter of the reef site (Figure 2-87).

2.2.8.3 Archaeological and Cultural Resources

There is evidence of human occupation along the Atlantic seaboard for about 12,000 years. Over this period of time the landscape has changed drastically, particularly along the coast which has moved inland due to sea level rise associated with the end of the last Ice Age. At the maximum of the last glaciation (the Wisconsin), circa 18,000-20,000 years before the present (BP), global sea levels were about 120 meters below the present level. The rate of sea-level rise slowed by circa 6,000 BP and, by 3,000 BP, the shorelines were close to their present position (Fairbanks 1989; Flint 1971; Kraft 1977; Stright 1995).

Potential submerged cultural resources on the continental shelf include Native American sites dated before about 3,000 BP (Paleoindian through the Late Archaic-Early Woodland transition) and historic ships and cargoes. There are many documented vessels sunk in this area and potentially other undocumented vessels and sites. Known shipwrecks are tracked by databases maintained by MMS and NOAA (Figures 2-84 to 2-87). Very few known shipwrecks have had their locations verified by groundtruthing. As a result, remote sensing surveys using side-scan sonar and magnetometer are necessary for locating both the "known" shipwrecks within a proposed project area and any that are not currently documented. For example, in 1993, the Maryland Historic Trust and MGS conducted a preliminary submerged cultural resource survey in order to evaluate the potential for cultural resources within offshore areas (Bilicki and Strout 1998). Acoustic remote-sensing methods, side-scan sonar and seismic reflection, were used to identify anomalies that could represent submerged cultural resources. These remote sensing techniques have been used effectively to locate anomalies that could represent shipwrecks and relict landforms such as buried stream valleys where prehistoric archaeological sites are likely to occur. However, because the remains of prehistoric hunter-gatherer sites generally do not have sufficient vertical dimension or acoustic contrast to be differentiated from natural sedimentary sequences by remote sensing methods, physical sampling of the landforms deemed to have archaeological potential is usually required (Stright 1986).

The earliest recognized prehistoric populations in North America were hunter-gatherer groups that are referred to collectively as Paleoindians. These groups are typically recognized by distinctive fluted, lanceolate spear points that have been found in association with megafaunal species that became extinct at the end of the Ice Age. The Paleoindian period in the Atlantic seaboard is typically dated from circa 12,000 BP to 8,500 BP.

At the beginning of the Paleoindian period, the Wisconsin ice margin had receded north of the project area and sea level would have been approximately 100 meters lower than the present level. This would have exposed a large area of the continental shelf, possibly as far as 150 km east of the present coastline. As a result, many present-day islands would have been connected to the mainland and what is now coastal terrain would have been well inland. Land bridges were created by the lowered sea levels, providing routes of travel for these migratory hunter-gatherer groups, and land now submerged on the continental shelf would have been available for human habitation (Pickman 1994). Features on this exposed shelf that would

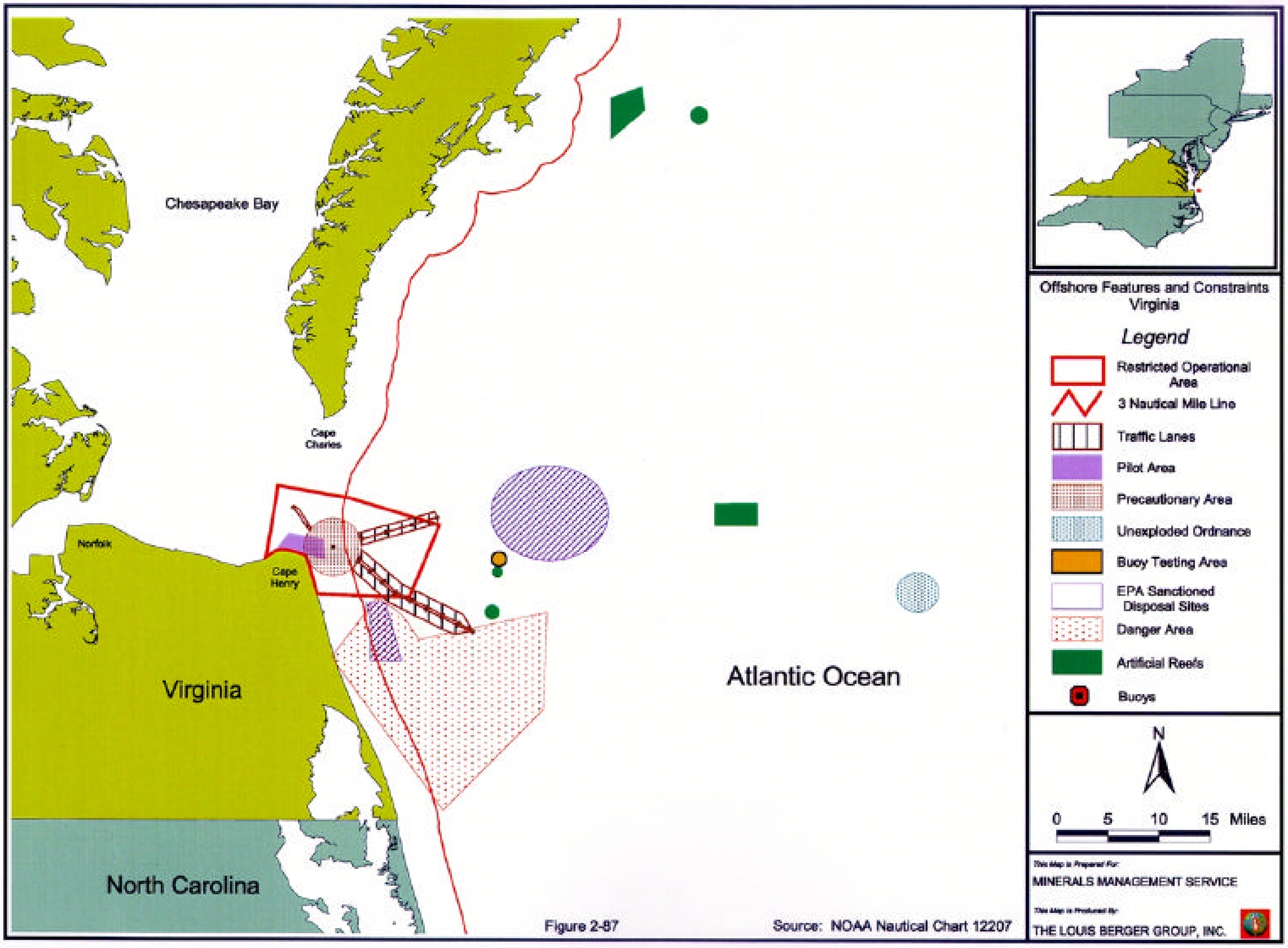


Figure 2-87. VA Reef Sites and Shoal Regions

have attracted human occupation include former freshwater sources, lithic outcrops, and barrier islands. These features vary with locale and would require evaluation on a case-by-case basis.

During the period of glacial retreat, the regional vegetation changed from an open, spruce forest to a mixed hardwood vegetation in the uplands and grasses and wetlands forests in the lowlands (Sirkin 1976). Changes in faunal communities accompanied the shifts in climate and vegetation. Large cold-adapted species, such as mammoth, mastodon, and caribou, were replaced by more temperate species, such as white-tailed deer. With the rise in sea levels, the Atlantic coastal region experienced changes that would have had an enormous effect on potential for population movements and resource exploitation.

The warmer Holocene climates that led to the retreat of the glaciers and rise of sea levels also caused vegetational changes such as the spread of deciduous forests. These environmental changes encouraged population migrations and the development of new subsistence strategies. The prehistoric period associated with these trends is known as the Archaic period and is typically dated circa 9,500-3,000 BP. Through the Archaic, population aggregations became larger and settlements more permanent.

The Woodland period that followed the Archaic is traditionally associated with the occurrence of ceramics. The introduction of ceramics in the Early Woodland, circa 3,000 BP, however, does not appear to represent a break with the lifeway patterns of the terminal Archaic. Trends continued toward greater sedentism and subsistence specialization, including the experimentation with cultivated plants. Increased social complexity is characterized by long-distance trade in exotics, mortuary ceremonialism, and mound building. These activities culminated in the Middle Woodland cultures, ca. 400 BC-AD 900. The Late Woodland period, from AD 900 to European contact, is represented by the appearance of large villages, which are often fortified, and a greater emphasis on farming.

The potential for intact prehistoric resources on the submerged continental shelf is difficult to assess and verify. Remains of Pleistocene and early Holocene fauna, including mastodon and mammoth, have been retrieved, for example by fishermen trawling for clams and scallops off the coast of New Jersey (Edwards and Emery 1977). Prehistoric artifacts have reportedly also been recovered from clam dredgers off the New Jersey coast, including a granite mortar found about 7 miles southeast of Manasquan at a depth of about 50 feet; however, no systematic archaeological investigations to locate intact sites have ever been conducted in this area (Pickman 1994). Native American artifacts have also been found along beaches, but their origin cannot usually be determined although it is possible that they washed up on beaches from eroded offshore sites.

It is presumed that many earlier coastal sites have been inundated by rising sea level. As these areas became inundated by a transgressive sea, they would have been subjected to processes that affect exposed beaches including movement of sand and storm damage. These cyclical erosional processes would presumably have destroyed the context of the majority of potential prehistoric sites on the continental shelf, as the estimated depth of erosion caused by the transgressing shoreface along the Atlantic Ocean is five to 10 meters (Edwards and Merrill 1977; Stright 1995). In some circumstances, it is possible that sites have been preserved if they were buried by sediments greater in thickness than the depth of wave scour prior to marine transgression. Environments in which such situations may have occurred include relict river terraces, floodplains, bays, lagoons, and lakes (Pickman 1994; Stright 1986). The types of sediments found on the continental shelf that may be indicative of depositional environments associated with higher sensitivity for preserved prehistoric resources include peat or organic silt layers, which would represent former estuaries or lagoon environments, and silts and clays deposited on floodplains and lake bottoms. Sands and gravels would have a low potential for containing preserved sites. Detailed sediment and geophysical data is required, therefore, in order to develop paleogeographic reconstructions that are

sufficient for defining sensitivity for intact prehistoric sites on the continental shelf (Pickman 1994; Stright

1986).

Among the tabulated archaeological sites identified on the inundated continental shelf, most are shell middens found in present lagoon setting; no submerged sites have been recorded from the continental shelf of New Jersey, Delaware, Maryland, or Virginia (Stright 1995). Shell midden are often easy to identify because of the accumulated shell refuse which resists erosion. Although there is some evidence for the use of shellfish resources beginning in the Early Archaic (Brennan 1976), these types of sites are not frequent until the Late Archaic and Early Woodland periods, when sea levels neared their present level and coastal and estuary systems stabilized.

2.2.8.4 Infrastructure

There are four working Trans-Atlantic submarine cables and two out of service cables that originate in central New Jersey. Manasquan Inlet, NJ is the current site for the installation of two more TAT cables. (M. Kutzlub, Phoenix Co., pers. comm., Feb. 1999). The major Trans-Atlantic telecommunications (TAT) companies owning and operating submarine cables are AT&T, Sprint, MCI, and GCL. Local cable lines do exist and there is also a possibility of creating a new link between New York and the Caribbean. There are no charted submarine cables originating in the remaining coastline of the Mid-Atlantic region that effect the study area. Yet, additional uncharted submarine cables and pipelines may exist within a charted area. There are inshore, local submarine cables and pipelines that connect the mainland to nearby barrier islands or barrier islands to barrier islands. These are identified on NOAA nautical charts (see Figures 2-84 to 2-87).

2.2.8.5 Shipping and Navigation

The coastal regions and adjacent waterways of the states of New Jersey, Delaware, Maryland, and Virginia contain 7 of the nation's 100 leading ports. These ports include New York (NY and NJ), Paulsboro NJ, Camden-Gloucester NJ, Philadelphia PA, Baltimore MD, Norfolk VA, and Newport News VA. Of these 7 ports, 6 are in the top 35 leading US ports for the import, export and domestic transport of goods, with approximately 311.8 million short tons shipped in 1997 collectively (USACE 1998e). Major shipping lanes radiate seaward from Delaware Bay, Chesapeake Bay, and New York Harbor. Traffic Separation Schemes (TSS) for each shipping lane are provided on NOAA nautical charts (Figures 2-84 to 2-87). A TSS is an internationally agreed plan for vessel traffic in congested areas. One-way shipping lanes are used to lessen danger of collision in these high volume areas of navigation. Other ports of embarkation include local fishing ports that dot the coastline in the states of the Mid-Atlantic region. Fishing traffic emanates from all inlets that connect to the Atlantic Ocean. Waterways that incorporate TSSs indicate an area of navigational congestion and it is recommended that these shipping lanes remain unhindered.

Port of New York and New Jersey

The Port of New York and New Jersey is the largest container port on the east coast of the United States. It was ranked as the third leading port in the nation for total commerce with over 135 million short tons transported domestically and foreign in 1997.

Port of Philadelphia

The Port of Philadelphia is the world's largest inland freshwater port with a total commerce of 45 million tons of goods imported and exported. Altogether, the combined ports on the Delaware River transport more than a million tons of goods annually. This area is also has the largest petrochemical complex on the East

Coast, consisting of seven major oil refineries. The area also hosts a large naval complex that is leased to private industry.

Port of Baltimore

The diversified Port of Baltimore handles millions of tons of bulk commodities. These include coal, iron ore, grain, and asphalt. The port ranks first in two-way international roll-on/roll-off cargo and transported approximately 14.8 million short tons of goods in 1997. It is considered the closest Atlantic port to Midwest manufacturing centers.

Port of Norfolk

The Port of Norfolk is the world's largest exporter of coal and contains one of the largest concentrations of naval installations worldwide. In 1997, more than 67 million tons of commerce moved through the port. Norfolk is host to a large number of military installations and has the greatest concentration of navy personnel on the East Coast. Information about the naval presence in the area is located in the Military Areas section of this report.

2.2.8.6 Military Areas

A number of the barrier islands within the Mid-Atlantic were historically used as artillery ranges in WWI and WWII. These nearshore areas contain various ordnance from training or firing activities and may contain unexploded ordnance. These areas, known as firing fans, are located at Sandy Hook NJ, Cape May NJ, Bethany Beach DE, Cape Henry VA, and Assateague Island VA (C. Spaur, USACE, pers. comm. Feb. 1999) (Figures 2-84 and 2-87). Ordnance offshore Cape May Point's concrete bunker has a designated 11-mile firing fan by the USACE. Shells were found at Bethany Beach DE on the beachface after inshore dredging was accomplished near Ft. Miles firing range (E. Charlier, USACE, pers. comm. Feb. 1999). Two rocket bombing ranges were established on Assateague Island between 1944 and 1947. The first formerly used defense site (FUDS) is located approximately 8.6 miles south of Ocean City Inlet and the other is immediately adjacent and seaward of Green Run Bay. Both sites are located on the island and nearshore to the island. Coordinate boundaries of each site are not certain (C. Spaur, USACE, pers. comm., March 1999). Cape Henry's danger area is already plotted on NOAA charts.

The military has historically conducted and continues to conduct a variety of exercises and maneuvers along the Atlantic coastline in U.S. ocean waters. The periodicity of usage can be obtained in the USCG monthly publication, *Local Notice to Mariners*. The notice also includes other areas of possible activity, limited access, and closure due to military exercise consisting of target practice, bombing, rocket firing, mine sweeping, and any other hazardous operation that would hinder safe passage of any vessel. The First Coast Guard District and Fifth Coast Guard District publications represent those areas and regions bordering New Jersey, Delaware, Maryland, and Virginia. The First District Local Notice to Mariners has information concerning the coastal waters from Eastport, Maine to Shrewsbury, New Jersey. The Fifth District publication includes information about the area from Shrewsbury River, NJ to Little River, SC.

Currently, New Jersey contains two firing ranges that reach seaward. The first region is offshore Sea Girt and is marked by lighted buoys on its extreme offshore borders. Firing commences on weekends between the hours of 7 a.m. and 6 p.m. during the period of April 1 to November 30. During the period of January 1 to December 31, firing takes place weekdays between the hours of 7 a.m. to 12 p.m.. The second area of concern is the USCG Rifle Range offshore Cape May. No vessel may enter the area during daylight hours unless authorized by the proper authority (Figure 2-85).

The southern portion of the Chesapeake Bay has an extremely high concentration of military facilities, consisting of all the branches of armed forces. One region of importance is the Air Force Practice Bombing, Rocket Firing, and Gunnery Range located offshore Myrtle Island, Virginia. The regulation states that no vessel shall enter the area except during intervals specified by local newspaper or radio announcement. Another area of concern is offshore Wallops Island, Virginia where rocket-launching operations occur. This danger area is open to vessels at all times unless warning signals are initiated. Vessels must leave the area immediately and may not reenter until the appropriate signals are issued. Other danger areas do exist, but the majority is not within the study area. Most of these danger areas are annotated on the appropriate NOAA nautical charts. Those danger areas that may directly affect the study area are annotated on the various figures for quick reference (Figures 2-84 to 2-87).

2.2.8.7 Dredged Material Placement Sites

The Marine Protection, Research, and Sanctuaries Act of 1972 (MPRSA) directs the EPA, in association with the USACE, to recommend sites for permitted ocean dumping and to control the dumping of these waste materials in U.S. waters. The objective in allocating sites and permits for specific waste material is to minimize environmental impacts to the marine environment and to match the appropriate waste material with its corresponding dump site. Beginning in the late 1980's, disposal at many designated sites in the New York Bight were discontinued and the sites dedesignated (Table 2-28). The location of both present and historic disposal sites in the New York Bight Apex are shown on Figure 2-84. Only those materials that meet stringent environmental criteria may be disposed of in a designated, ocean dump site. For New Jersey, Delaware, Maryland, and Virginia, the EPA has designated on a final basis, seven dredged material disposal sites. Of these, five are located offshore New Jersey and two are offshore Norfolk, Virginia (Figures 2-84 and 2-87). A brief summary of each is given below.

Historic Area Remediation Site, NY/NJ

The Historic Area Remediation Site (HARS), formerly known as the Mud Dump Site, is a 15.7 square nautical mile area located 7.7 nautical miles south of Rockaway, Long Island and 3.5 nautical miles east of Highlands, New Jersey (Figure 2-84). It contains the original Mud Dump Site, a Primary Remediation Area (PRA), a Buffer Zone encompassing the PRA, and a No Discharge Zone (NDZ). The NDZ is a 1.0 square nautical mile site where placement of material is not allowed (USEPA 1997).

Shark River Dredged Material Placement Site, NJ

The Shark River Dredged Placement Site is approximately 0.6 square nautical miles in area and 12 meters in depth. It is located roughly 1.4 nautical miles northeast of Belmar, New Jersey and 3 nautical miles southeast of Elberon, New Jersey. It is currently in use and restricted to dredged material excavated from the Shark River Inlet.

Manasquan Dredged Material Placement Site, NJ

The Manasquan Dredged Material Placement Site is 0.11 square nautical miles in size and approximately 18 meters in depth. The site is situated roughly 1 nautical mile northeast of the mouth of Manasquan Inlet. It is currently in use and restricted to dredged material placement for projects occurring in Manasquan Inlet.

Table 2-28. History of Ocean Disposal Sites in the New York Bight

Site Name	Material Disposed	Key Dates or Initial Year of Use	Year of Interim (I) and Final (F)	Final Year of Site Use	Site De-designation

			Designation		Year
12-Mile Site	**Sewage Sludge**	**1924**	**1973 (I) 1979 (F)**	**1987**	**1990**
Acid Waste Site	**Industrial acid waste byproducts**	**1948**	**1973 (I) 1983 (F)**	**1988**	**1991**
Cellar Dirt Site	**Construction and excavation debris**	**1940s**	**1973 (I) 1983 (F)**	**1989**	**1994**
Wood-burning Site	**Wood pilings and other navigation hazards from Harbor**	**1960**	**1973 (I)**	**1991**	**De-designation in process (Use of this site has been prohibited since 12/31/93 under WRDA 1990)**
106-Mile Deepwater Municipal Sewage Sludge Disposal Site	**Mixed waste types prior to final site designation (1960s – 1980s); Multiple wastes including acid iron waste and sewage sludge; sewage sludge only after final site designation**	**1986**	**1984 (F)**	**1992**	**1994**
106-Mile Site (Industrial)	**Industrial wastes**	**1960s**	**1984 (F)**	**1987**	**1990**
Inlet sites (Dredged material sites)	**Inlet maintenance sediments**	**1990**	**1990 (F)**	**Active**	**NA**
New York Bight Dredged Material Disposal Site (HARS)	**Dredged material**	**1973**	**1973 (I) 1984 (F)**	**Active**	**NA**

Source: USEPA 1997.

Absecon Inlet Dredged Material Placement Site, NJ

The Absecon Dredged Material Placement Site is 17 meters in depth and 0.28 square nautical miles in area. The dump site is approximately 4.4 nautical miles east of Atlantic City, New Jersey and 10.2 nautical miles south from the southern tip of Long Beach Island, New Jersey. It is used for the dredged material placement from Absecon Inlet.

Cold Spring Inlet Dredged Material Placement Site, NJ

The Cold Spring Inlet Dredged Material Placement Site is located approximately 0.75 nautical miles southeast of Cape May Point, New Jersey. The site is about 0.3 square nautical miles in size and 9 meters in depth. It is currently being utilized and limited to the placement of dredged material from Cold Spring Inlet.

Dam Neck Dredged Material Placement Site, VA

The Dam Neck Dredged Material Placement Site has been in use since 1967 (C. Seltzer, USACE, pers. comm., Feb. 1999). This site is 8 square nautical miles in size and has an average depth of 11 meters. The disposal area is located roughly 2.6 nautical miles east of Virginia Beach, Virginia. It is currently being used and limited for the placement of dredged material originating from the mouth of the Chesapeake Bay (Cape Henry and Thimble Shoals Channels) (C. Seltzer, USACE, pers. comm., Feb. 1999).

Norfolk Dredged Material Placement Site, VA

The Norfolk Dredged Material Placement Site is circular in shape, has a radius of 4 nautical miles, and encompasses an area of 50 square miles. Its depth ranges from 13 to 26 meters and its use is limited to suitable dredged material that meets the environmental criteria for ocean dumping. This site is approximately 10 nautical miles southeast of Smith Island, Virginia and 14 nautical miles east of Cape Henry Point. The center of the site is located 17 nautical miles east of the mouth of the Chesapeake Bay. This site has been used since the late 1980's or early 1990's and received EPA final designation in 1993 (C. Seltzer, USACE, pers. comm. Feb., 1999).

2.3 Beaches/Onshore Habitats

2.3.1 Physical Environment

The following sections review the existing conditions of sediment transport rates, ocean wave environments, and littoral sediment characteristics for the Atlantic Coastline from Sandy Hook, New Jersey to Virginia Beach, Virginia (Figure 1-1). The necessary data for each section of the coastline was obtained primarily from USACE reports (*e.g.*, USACE 1995, 1997a, 1998d, 1998e). A table listing the relevant reports and beach nourishment projects for each section is provided below (Table 2-29). Overall, the water quality along beaches within the study area is very site-specific. The relevant water quality parameter for beach nourishment projects is primarily turbidity, assuming the source sediments are not contaminated. Turbidity levels along ocean beaches depend on the sea state. During storms, the turbidity levels in the surf zone are high. Dissolved oxygen concentrations along beaches are typically high due to the turbulence in the surf zone (with the exception of the vicinity of stormwater outfalls), although dissolved oxygen concentrations are higher in the winter and lower in the summer.

The regional and longshore current pattern displayed by the four states within the study area consists of currents which separate and flow in opposite directions from a nodal zone (*e.g.*, Ashley *et al.* 1986). Seasonal variation in wave approach, large-scale wave refraction, and residual drift of ocean currents on the shelf interact and play a role in the persistent current pattern.

2.3.1.1 New Jersey

Uptegrove *et al.* (1995) provided an overview of New Jersey beaches and characterized the potential offshore sediments as replenishment sources. New Jersey beaches are comprised of unconsolidated sand, silt and gravel reworked from Cretaceous, Tertiary, and Quaternary Coastal Plain sediments (McMaster 1954). In the northern portion of the coast approximately from Long Branch south to Point Pleasant Beach, the Coastal Plain sediments are directly exposed to wave action. The modern beach lies directly seaward of a bluff which rises as much as 26 feet above the beach. Major storms erode the beach and dune cover and the bluff as well. In the southern portion of the coast from Mantoloking to Cape May Point, there are no exposed Cretaceous and Tertiary Coastal Plain sediments. Within the region, beach sands reworked from submerged Coastal Plain sediments mingled with eroded onshore sediments transported from the northern bluffs by longshore currents form a series of barrier islands ranging from five miles (Wildwoods) to 18 miles (Long Beach Island) long. Along the coast from Point Pleasant southward, the beaches contain progressively less material derived from the bluffs present in Monmouth County. South of Long Beach Island, the average diameter of sand grains is half of those on the northern beaches. In addition, the trace

Table 2-29.
Summary of Current Federal Beach Nourishment Projects, New Jersey to Virginia
(Data Compiled from Various USACE Studies & Reports 1980-1998)

Project	Data Source	Initial Fill	Renourishment Period/CY	Renourishment Annualized - CY
Sea Bright to Ocean Township, NJ Sea Bright*, Monmouth Beach*, Long Branch	NY USACE: GDM, 1989 Revised March, 1990	17,705,400	6/3,522,000	587,000
Asbury Park to Manasquan, NJ North Reach: Asbury Park, Avon-by Sea South Reach: Belmar, Spring Lake, Sea Girt, Manasquan	NY USACE: GDM, 1994 Revised January, 1995	4,864,700	5/2,747,253	549,450
Manasquan Inlet to Barnegat Inlet, NJ Mantoloking, Lavallette, Seaside Heights	Phila. USACE: Recon. Study March, 1996	1,312,000	3/292,500	97,500
Barnegat Inlet to Little Egg Harbor Inlet, NJ Zone 1: Loveladies, Harvey Cedars, North Beach Zone 2: Brant Beach, Brighton Beach Zone 3: Beach Haven, Holgate	Phila. USACE: Recon. Study March, 1995	6,451,244	3/1,437,480	479,160
Brigantine Inlet to Great Egg Harbor Inlet Brigantine Island	Phila. USACE: IFS, November, 1997	648,000	6/312,000	52,000
Absecon Island; Atlantic City, Ventnor, Margate, & Long Port, NJ	Phila. USACE: IFS, August, 1996	6,174,013	3/1,666,000	555,333
Great Egg Harbor Inlet to Townsend Inlet Ocean City/Peck Beach* Peck Beach: So. Ocean City, Carsons Ludlum Island: Sea Isle City, Strathmere/Whale Beach	Phila. USACE: GDM, May, 1990 Phila. USACE: Recon. Study April, 1996	4,118,000	3/1,072,000	357,333
Townsends Inlet to Cape May Inlet AvaIon, Stone Harbor, North Wildwood	Phila. USACE: FS December, 1996	4,477,000	3/986,000	328,666
Lower Cape May Meadows to Cape May Point, NJ Cape May Meadows	Phila. USACE: FS August, 1998	1,722,000	4/650,000	162,500
TOTAL NEW JERSEY		**47,472,357**		**3,168,942**
Delaware Coast - Cape Henelopen to Fenwick Island Rehoboth Beach/Dervy Beach	Phila. USACE: FFS June, 1996	1,437,272	3/360,000	120,000
Bethay Beach/South Bething, DE	Phila. USACE: FFS January, 1998	3,453,000	3/480,000	160,000
TOTAL DELAWARE		**4,890,272**		**280,000**
Ocean City, Maryland and Vicinity Ocean City*	Baltimore USACE: GDM August, 1989	3,800,000	---	175,000
Assateague Island	Baltimore USACE: FS August, 1980	1,800,000	---	189,000
TOTAL MARYLAND		**5,600,000**		**364,000**
Virginia Beach and Vicinity Virginia Beach*	Norfolk USACE: GDM November, 1983	5,000,000	3/765,000	255,000
Sandbridge	Personnel Interviews, 1999	3,000,000	---	500,000
TOTAL VIRGINIA		**8,000,000**		**755,000**

Key to Source Reports: GDM-General Design Memo., Recon. Study-Reconnaissance Study, IFS-Interim Feasibility Study, FFS-Final Feasibility Study
* Projects recently constructed. (1990-1998)

metals interspersed with the predominantly quartz sand differs from that present in the northern sands. This suggests that the sand on the southern coast barrier islands has been derived from sources other than the northern bluffs or that it has been reworked after deposition and later sea-level rise.

The New Jersey Beach Profile Network (NJBPN) has collected data from 1986 on the annual shoreline and beach face conditions as well as erosional and depositional trends of New Jersey beaches. These data have been collected by the Stockton State College Coastal Research Center (CRC). There are 90 profile stations located 1,000 ft apart along the Atlantic coast. The New Jersey Atlantic Coast profile data are organized into 13 segments called reaches.

Sea Bright-Ocean Township

This segment of the study area includes approximately 12 miles (19.3 km) of shoreline extending from just north of the Route 36 bridge in Sea Bright, southward to Ocean Township at the outlet of Deal Lake. The entire study area is located within Monmouth County. The segment contains Reach 2 and a portion of Reach 3 of the New Jersey Atlantic Coast profile network. The segment is intensely developed and heavily armored with seawalls.

- ***Sediment Transport***

Southeastern wave directions predominate in this region, resulting in a net littoral drift from the south to the north. The sediment budget evaluation is based on the historical net northward littoral drift potential of 493,000 yd^3/yr (377,000 m^3/yr) at the north end of the study area. The amount of sediment entering the south boundary near Deal Lake has reduced over time from 319,000 yd^3/yr (244,000 m^3/yr) to 155,000 yd^3/yr (119,000 m^3/yr). The resulting sediment deficit is partially responsible for the shoreline erosion rate from 1953 through 1985 of 349,000 yd^3/yr (267,000 m^3/yr). Of the erosion volume, 112,000 yd^3/yr (86,000 m^3/yr) is lost offshore while 237,000 yd^3/yr (181,000 m^3/yr) of sediment is transported north to Sandy Hook. The combined transport rate of 392,000 yd^3/yr (300,000 m^3/yr) moves across the northern project boundary into Sandy Hook where an additional 148,000 yd^3 (113,000 m^3) are supplied by the Critical Zone annually. Of this material 47,000 yd^3 (36,000 m^3) are lost offshore and 101,000 yd^3 (77,000 m^3) are sustained in the littoral transport.

- ***Wave Environment***

An analysis of general wave statistics for the study area is presented in a report entitled 'Hindcast Wave Information for the U. S. Atlantic Coast' (Wave Information Study (WIS) Report 30). WIS Report 30 supersedes WIS Report 2 (Corson *et al.* 1981), WIS Report 6 (Corson *et al.* 1982), and WIS Report 9 (Jensen 1983). The investigation used meteorological data between 1956 and 1975 and the present version of the WIS wave model, WISWAVE 2.0 (Hubertz 1992), to back calculate the resulting incident wave fields. The wave statistics include: 'significant wave height', which is the average height of the highest one-third of the waves during the given time interval; 'wave period', which is the period corresponding to the peak in the wave energy-period spectrum; and 'wave direction', which is the mean direction from which the waves are approaching relative to the shoreline orientation. Wave height may be reported as average or significant wave heights. The hindcast investigation for this segment determined the average wave height to be 1.5 feet (0.46 m), with 63 percent of the waves less than 1.6 feet (0.49 m), 25 percent of the waves between 1.6 feet (0.49 m) and 3.3 feet (1.01 m) and 12 percent of the waves greater than 3.3 feet (1.01 m).

- ***Littoral Sediment Characteristics***

Beach samples were taken along 16 USACE profile lines from Sandy Hook to Belmar. A composite grain size distribution curve was developed for each profile. The average mean grain size is approximately 1.77 phi (0.29 mm) with a standard deviation of -0.96 phi (1.95 mm).

Asbury Park - Manasquan Inlet

This segment of the study area extends along a nine mile (14.5 km) length of shoreline from Asbury Park southward to the north jetty of Manasquan Inlet. It incorporates Shark River Inlet, a federal navigation channel, located north of the center of the study area. The segment contains a portion of Reach 3 and all of Reach 4 of the New Jersey Atlantic Coast profile network. The segment is intensely developed and heavily armored with seawalls.

- ***Sediment Transport***

Table 2-30 depicts an existing conditions sediment budget prepared for the entire study area. The amount of sediment entering the southern border has been reduced from the historical potential of 74,000 yd^3/yr (57,000 m^3/yr) to 56,000 yd^3/yr (43,000 m^3/yr). At Shark River Inlet the littoral drift rate is 147,000 yd^3/yr (112,000 m^3/yr). The longshore sediment transport rate increases across the northern boundary to 155,000 yd^3/yr (119,000 m^3/yr). Both littoral drift rates at Shark River Inlet and the northern boundary have been reduced from their historical potential rates of 236,000 yd^3/yr (180,000 m^3/yr) and 319,000 yd^3/yr (244,000 m^3/yr) respectively. The shoreline supplied 155,900 yd^3 (119,000 m^3) annually. Of this eroded material 56,900 yd^3 (44,000 m^3) were lost offshore, while the remaining 99,000 yd^3 (76,000 m^3) were entrained in the longshore transport. Some of the eroded sediment was supplied by dredging of Manasquan and Shark River Inlets.

- ***Wave Environment***

This segment experienced a similar wave climate as Sea Bright and Ocean Township, with predominant wave directions from east and southeast. The average wave height in this region was 1.5 feet (0.46 m), with 63 percent of the waves less than 1.6 feet (0.49 m), 25 percent of the waves between 1.6 feet (0.49 m) and 3.3 feet (1.01 m) and 12 percent of the waves greater than 3.3 feet (1.01 m). The largest wave observed was 22.5 feet (6.9 m), which occurred once during the 20 year period.

- ***Littoral Sediment Characteristics***

Beach sediment samples were taken from Asbury Park to Point Pleasant at various elevations ranging from +12 ft. (3.66 m) to -30 ft. (-9.14 m) MLW at 6 foot (1.83 m) intervals. A composite grain size distribution curve vas developed for each profile. The average mean grain size varies from 1.55 phi (0.34 mm) to 2.32 phi (0.20 mm).

Manasquan Inlet - Barnegat Inlet

This segment of the study area is centrally located along the open coastline of New Jersey, entirely within Ocean County. The land mass which is approximately 24 statute miles (38.6 km), extends from Manasquan Inlet to Barnegat Inlet, and is referred to as Island Beach. The segment corresponds to Reach 5 and 6 of the New Jersey Atlantic Coast profile network. The general shoreline orientation is north-northeast to south-southwest. The segment comprises some of the most stable sections of the New Jersey coastline

Table 2-30. Longshore Sediment Transport Rates

Location	Source	Type and Data Base	Gross Transport (cu yd/yr)		Net Transport (cu yd/yr)
			North	South	
Manasquan Inlet	CERC/CENAP 1966 Barnegat Phase I	Longshore wave energy @ 30 ft contour before 1954	1.98 M	130,000	1.85 M n
Manasquan Inlet	CENAN-1954	1930-1931			360,000 n
Manasquan Inlet	Caldwell 1966	Survey comparison, 1838-1953			74,000 n
Manasquan Inlet	Douglas and Weggel Drexel 1986	WIS data and energy flux method (1956-1974)	500,000	220,000	280,000 n
Manasquan Inlet	CENAP	LEO data, June 1982 to October 1984	600,000	1.2 M	600,000 s
Manasquan Inlet	PRC Harris	Wave data and refraction			301,000 n
Manasquan Inlet	Farrell 1980	Shoaling rates; aerial photos (5/65-10/77)			45,070 n
Manasquan Inlet	Bruno 1988	Dredging, shoaling rates; surveys			30,000 to 74,000 n
Manasquan Inlet	Bruno 1988	Tracer and hindcast			135,550 n
Dover Township	CENAP House Doc #91-160	1955-1963	500,000	500,000	0

(Utegrove *et al.*, 1995). The beaches are relatively steep, but the seabed slope is more gradual than it is to the north, and few armored shorelines are present.

- ***Sediment Transport***

Several studies have derived transport rates for this study region (Table 2-30). Estimates of gross longshore sediment transport vary from as low as 750,000 yd^3/yr (573,000 m^3/yr) to over 2,000,000 yd^3/yr (1,500,000 m^3/yr), with net northward littoral drift rates ranging from 30,000 yd^3/yr (23,000 m^3/yr) to 2,000,000 yd^3/yr (1,500,000 m^3/yr). A preliminary analysis of sediment transport quantities for Island Beach was conducted using programs from the Shoreline Modeling System. Results of this analysis determined an average net transport rate to the north of approximately 215,000 yd^3/yr (164,000 m^3/yr).

- ***Wave Environment***

Waves predominantly approach the study region from a southward orientation relative to the shoreline, which generates a prevailing northward longshore current. The average wave height in the study area is approximately 2-3 feet (0.61-0.91 m) with a period of 6 seconds. Storm waves in this region have been recorded in excess of 20 feet (6.1 m).

- ***Littoral Sediment Characteristics***

Island Beach is comprised of quartz sand with a median grain diameter of 1.08 phi (0.47 mm).

Barnegat Inlet - Little Egg Harbor Inlet

This segment of the study area, located on the middle Atlantic coast of New Jersey in Ocean County extends approximately 20.8 miles (33.5 km) from Barnegat Inlet to Little Egg Inlet. The segment corresponds to Reach 7 of the New Jersey Atlantic Coast profile network. This sandy barrier island, known as Long Beach Island, has 18 miles (29.0 km) of developed shoreline with few hardened shoreline structures, with a general axis of orientation from north-northeast to south-southwest.

- ***Sediment Transport***

Estimates of gross longshore sediment transport (Table 2-31) range from 500,000 yd^3/yr (382,000 m^3/yr) to 2,000,000 yd^3/yr (1,500,000 m^3/yr). Net southward transport rates vary from 50,000 yd^3/yr (38,000 m^3/yr) to 400,000 yd^3/yr (306,000 m^3/yr). The difference between estimated north and south transport quantities are not extremely large with respect to the gross sediment transport value, therefore, reversals in longshore sediment transport contribute significantly to both the short and long term behavioral patterns of the Long Beach shoreline.

Table 2-31. Prior USACE Estimates of Longshore Sediment Transport
(Long Beach Island, NJ and Vicinity)

		Gross Transport (1000's of cu yd/yr)			Net Transport
General Location	**Data Base**	**North**	**South**	**Total**	**(1000's of cu yd/yr)**
Barnegat Inlet	1972-1975	720	860	1,580	140 south
	1972	1,000	890	1,890	110 north
	1973	540	700	1,240	160 south
	1974	780	930	1,710	150 south
	1975	560	930	1,490	370 south
Long Beach Island	1838-1953	500	550	1,050	50 south
	1974	250	300	550	50 south

- ***Wave Environment***

Hindcast average significant wave heights for Long Beach Island ranged from 1.8 to 2.0 feet (0.55-0.61 m), with largest significant wave heights on the order of 13.0 feet (4.0 m). The highest waves were found to approach the coast most frequently from the east-northeast.

- ***Littoral Sediment Characteristics***

Long Beach Island is comprised of quartz sand with a median grain diameter of 1.51 phi (0.35 mm).

Brigatine Inlet -Great Egg Harbor Inlet

Brigantine Island is approximately 6.5 miles (10.5 km) in length, extending from Brigantine Inlet to Absecon

Inlet. The segment corresponds to Reaches 8 and 9 of the New Jersey Atlantic Coast profile network. Brigantine Island contains the City of Brigantine and the North Brigantine State Nature Area at the northern end of the island. Absecon Island is approximately 8 miles (12.9 km) in length, bound by Absecon Inlet to the north and Great Egg Harbor Inlet to the south. Absecon Island contains the four communities of Atlantic City, Ventnor, Margate, and Longport.

- ***Sediment Transport***

The gross longshore transport rate for Brigantine Island is 600,000 yd^3/yr (459,000 m^3/yr) with a net southerly transport rate of 100,000 yd^3/yr (76,000 m^3/yr). Estimates of gross longshore transport rates for Absecon Island ranged from 306,000 yd^3/yr (234,000 m^3/yr) to 650,000 yd^3/yr (497,000 m^3/yr), with net southerly transport rates varying from 92,000 yd^3/yr (70,000 m^3/yr) to 150,000 yd^3/yr (115,000 m^3/yr). A summary of gross and net transport estimates for the segment is provided in Table 2-32.

Table 2-32. Historic Sediment Transport Rates for Brigantine and Absecon Islands

Location	Source	Gross Transport (cu yd/yr)		Net Transport (cu yd/yr)
		North	South	
Brigantine Island	House Document #94-631, New Jersey Coastal Inlets and Beaches – Barnegat Inlet to Longport	250,000	350,000	100,000 south
Absecon Inlet	CENAP Group I, II, III Report	500,000	600,000	100,000 south
Atlantic City	Caldwell MFR (4/18/58)	450,000	550,000	100,000 south
	Caldwell 1966 CERCR 1-67	500,000	600,000	100,000 south
Absecon Island	Wicker 1967 letter to Caldwell	107,000	199,000	92,000 south
	Caldwell 1968 letter to Wicker	250,000	400,000	150,000 south

- ***Wave Environment***

An analysis of general wave statistics for the study area is presented in a report entitled 'Hindcast Wave Information for the U. S. Atlantic Coast' (WIS Report 33). WIS Report 33 supersedes WIS Report 30, WIS Report 2 (Corson *et al.* 1981), WIS Report 6 (Corson *et al.* 1982), and WIS Report 9 (Jensen 1983). The investigation used meteorological data between 1976 and 1993 and the present version of the WIS wave model, WISWAVE 2.0 (Hubertz 1992), to back calculate the resulting incident wave fields. Waves generated by tropical storms and hurricanes were excluded from this analysis. The wave statistics include significant wave height, wave period, and wave direction. For the project area, monthly mean wave heights for the updated hindcast in WIS Report 33 range from 2.5 feet (0.76 m) in July to 5.2 feet (1.58 m) in March. The mean wave height for this study region for the period 1976 to 1993 is 4 feet (1.22 m) with a mean period of 8 seconds. The maximum reported wave height was 29.2 feet (8.90 m) with an associated peak period of 14 sec and a peak direction of 140° on Sept. 27, 1985.

- ***Littoral Sediment Characteristics***

A composite beach grain size curve was developed for Absecon Island. The native mean grain size is 2.36 phi (0.19 mm) with a standard deviation of 0.82 phi (0.57 mm). This corresponds to a poorly graded or well sorted, fine to medium sand.

Great Egg Harbor Inlet -Peck Beach, Ocean City

This segment of the study area consists of Great Egg Harbor Inlet and Peck Beach, Ocean City. The segment corresponds to Reach 10 of the New Jersey Atlantic Coast profile network. The barrier Island is approximately nine miles (14.5 km) in length and is bordered on the north by Great Egg Harbor Inlet and on the south by Corson's Inlet. Ocean City, is one of New Jersey's prime shore recreational centers.

- ***Sediment Transport***

In Ocean City, beach erosion is a major problem from Surf Road to 23rd Street. Wave refraction around the ebb-tidal shoal in conjunction with flood tidal currents through marginal flood channels has created a regional divergence in longshore transport. Littoral drift to the northeast and southwest occurs from the northeast and southwest ends of this area, respectively. In 1975 the USACE CERC performed a detailed transport analysis across this region using wave gage data and profile measurements from Atlantic City and Ludlam Island, in conjunction with aerial photographic measurements of shoreline location from Ocean City. CERC calculated a gross annual transport rate of 1,143,000 yd^3/yr (874,000 m^3/yr), with a net southerly transport into the Great Egg Harbor Inlet region of 379,000 yd^3/yr (290,000 m^3/yr) The inlet is responsible for trapping 154,000 yd^3 (118,000 m^3) annually, resulting in a net input to the northeast end of the Ocean City shoreline of 225,000 yd^3/yr (172,000 m^3/yr). Using aerial photo analysis of the Ocean City shoreline, CERC calculated a net deficit (erosion) of 180,000 yd^3/yr (138,000 m^3/yr). This sediment was added to the littoral drift resulting in a net sediment transport rate of 405,000 yd^3/yr (310,000 m^3/yr) towards Corson's Inlet.

- ***Wave Environment***

The wave statistics pertinent to the Ocean City-Great Egg Harbor Inlet study are derived from Station 68 of WIS Report 30 and 33, which is located offshore Peck Beach. The hindcasting procedure indicated that the waves predominantly originated from the southeast, with a higher energy regime occurring during the fall/winter period. This pattern of seasonal wave energy is typical of the northeastern Atlantic Coast. Monthly mean wave heights for the updated hindcast range from 2.5 feet (0.76 m) in July to 5.2 feet (1.58 m) in March. The mean wave height for this study region for the period 1976 to 1993 is 4 feet (1.22 m) with a mean period of eight seconds. The maximum reported wave height was 29.2 feet (8.90 m) with an associated peak period of 14 seconds and a peak direction of 140° on Sept. 27, 1985.

- ***Littoral Sediment Characteristics***

Sediment becomes progressively finer grained in the offshore direction, with the exception of the low and mid tide regions (Tables 2-33 and 2-34). High energy conditions in these regions result in coarser and more poorly sorted sediment. Sediment exhibits a slight fining southward along Peck Beach, which is consistent with previous investigations along Ocean City and the Atlantic Coast of New Jersey. The native beach material has a mean grain diameter of 2.64 phi (0.16 mm), with a mean sorting of 0.46 phi (0.73 mm).

Table 2-33. Phi Means, Variances, and Standard Error Profiles at Peck Beach, Ocean City, New Jersey May 1984

Location or Elev. (ft.)	Profile GE-8	GE-10	91	92	93	94	95	96	97	98	Depth Composite
Berm	2.51	2.45	2.43	2.07*	---	2.49	2.52	2.38	2.42	2.69	2.44
High Tide	2.40	2.46	2.62	2.22	2.27	2.47	2.36	2.21	2.42	2.51	2.39
Mid Tide	2.38	2.15	2.57	2.10	1.77	2.34	1.91	1.75	2.29	2.37	2.16
Low Tide	2.24	2.10	2.29	2.27	2.39	2.24	2.19	1.90	1.90	2.35	2.19
-3	2.24	2.56	2.19	2.43	2.68	2.76	2.88	2.61	2.62	2.51	2.55
-6	2.23	2.36	2.51	2.54	2.69	2.79	2.96	2.69	2.84	2.69	2.63
-12	2.07	1.83	2.44	2.60	2.73	2.65	3.07	2.89	2.96	2.90	2.61
-18	2.06	2.78	2.75	2.91	2.84	3.36	3.63	3.46	2.99	3.21	3.00
-24	1.88	3.15	2.92	3.36	3.12	3.32	3.27	3.46	3.45	3.49	3.14
-30	1.71	3.30	3.52	3.67	3.35	3.15*	3.26	3.47	3.56	3.75	3.27
Line Composite	2.17	2.51	2.62	2.62	2.65	2.76	2.81	2.68	2.75	2.85	$s^2 = 0.147$ $s_x = 0.128$

$s^2 = 0.038$ $s_x = 0.065$
Grand Phi Mean = 2.64
*Curve normalized to compensate for coarse shell fraction

Table 2-34. Phi Sorting From Profiles at Peck Beach, Ocean City, New Jersey May 1984

Location or Elev. (ft.)	Profile										Depth Composite
	GE-8	**GE-10**	**91**	**92**	**93**	**94**	**95**	**96**	**97**	**98**	
Berm	0.30	0.37	0.47	0.52*	---	0.53	0.33	0.36	0.36	0.35	0.40
High Tide	0.30	0.30	0.30	0.37	0.35	0.36	0.37	0.56	0.36	0.38	0.37
Mid Tide	0.28	0.47	0.34	0.49	0.78	0.46	0.64	0.76	0.49	0.44	0.58
Low Tide	0.38	0.42	0.37	0.47	0.41	0.49	0.60	0.74	0.63	0.46	0.50
-3	0.41	0.39	0.55	0.48	0.56	0.45	0.48	0.50	0.44	0.51	0.48
-6	0.39	0.36	0.39	0.41	0.54	0.48	0.51	0.43	0.40	0.46	0.44
-12	0.44	0.38	0.36	0.35	0.32	0.39	0.51	0.51	0.46	0.43	0.42
-18	0.43	0.48	0.43	0.38	0.34	0.47	0.37	0.42	0.55	0.52	0.44
-24	0.43	0.40	0.39	0.50	0.74	0.50	0.50	0.42	0.45	0.47	0.48
-30	0.47	0.49	0.40	0.36	0.59	0.68*	0.59	0.51	0.39	0.25	0.47
w10 **Line Composite**	0.38	0.41	0.40	0.43	0.51	0.48	0.49	0.52	0.45	0.43	
Grand Phi Sorting = 0.46											

* Curve nomalized to compensate for coarse shell fraction

Ludlam Island (Corson's Inlet -Townsend Inlet)

Ludlam Island extends 7.3 miles (11.7 km) and includes the towns of Strathmere and Sea Isle City. Ludlam Island is bound to the north by Corson's Inlet and to the south by Townsend Inlet and consists of mostly residential structures. The segment corresponds to Reach 11 of the New Jersey Atlantic Coast profile network. It is a low-lying shoreline under intense erosional pressure.

- ***Sediment Transport***

CERC calculated a gross transport rate for Sea Isle City of 1,143,000 yd^3/yr (874,000 m^3/yr), with a annual net southern transport of 429,000 yd^3 (328,000 m^3). Littoral drift was directed toward the south from September to May and toward the north in June and July. A longshore transport reversal node was identified approximately 1500 feet (450 m) south of Corson Inlet.

- ***Wave Environment***

Wave statistics pertinent to the Ludlam Island were also derived for Station 68 of WIS Report 30 and 33. Monthly mean wave heights for the updated hindcast range from 2.5 feet (0.76 m) in July to 5.2 feet (1.58 m) in March. The mean wave height for this study region for the period 1976 to 1993 was 4 feet (1.22 m) with a mean period of 8 seconds. The maximum reported wave height was 29.2 feet (8.90 m) with an associated peak period of 14 sec and a peak direction of 140° on Sept. 27, 1985.

- ***Littoral Sediment Characteristics***

The mean grain diameter for Ludlam Island ranged from 2.0 phi (0.25 mm) to 0.0 phi (1.0 mm). These estimates were inferred based on accepted borrow sites located offshore of Ludlam Island.

Townsend Inlet - Cape May Inlet -Avalon Stone Harbor

This segment of the study area, located in southern New Jersey, is approximately 15 miles (24 km) in length extending from Townsend Inlet to Cape May Inlet. The study area encompasses two barrier islands and two coastal inlets. Hereford Inlet separates Stone Harbor from Five Mile Beach. The segment corresponds to Reach 12 and 13 of the New Jersey Atlantic Coast profile network.

- ***Sediment Transport***

Net longshore transport along most of the study area is from northeast to southwest. There are local reversals in the littoral drift near Townsend and Hereford Inlets. There have been several investigations which have evaluated shore processes for the New Jersey coastline. CERC conducted a detailed analysis which incorporated the project area. This study determined the average annual net transport rates to the southwest to be 430,000 yd^3 (329,000 m^3) at Sea Isle City, 400,000 yd^3 (306,000 m^3) at Seven Mile Beach, and 250,000 yd^3 (191,000 m^3) at Wildwood/Two Mile Beach.

- ***Wave Environment***

Wave statistics pertinent to the study region are those derived for Station 67 of WIS Report 30. Monthly mean wave heights for Station 67 for the entire 20 year hindcast range from 2.4 feet (0.73 m) in August to 4.3 feet (1.31 m) in December and January. The maximum reported wave height was 23.6 feet (7.19 m) with an associated peak period of 14 sec and a peak direction of 97 deg. This occurred on March 7, 1962.

- ***Littoral Sediment Characteristics***

A composite beach grain size curve was developed for Seven Mile Island and North Wildwood. The mean grain size of Seven Mile Island is 2.4 phi (0.19 mm) with a standard deviation of 0.63 phi (0.65 mm). According to the Unified Classification System, this material is well sorted, fine sand. The mean grain size of North Wildwood is 2.47 phi (0.18 mm), with a standard deviation of 0.63 phi (0.65 mm). North Wildwood beaches are also comprised of well, sorted fine sand.

Lower Cape May Meadow-Cape May Point

This segment of the study area is located at the southern tip of New Jersey on the Atlantic Ocean side of the Cape May Peninsula and includes Lower Cape May Meadow, the Borough of Cape May Point, and the Borough of West Cape May. The segment corresponds to Reach 14 of the New Jersey Atlantic Coast profile network. The Meadow is approximately 1.3 miles (2.08 km) long and encompasses 343 acres containing Cape May State Park and the Cape May Migratory Bird Refuge. Cape May Point is a 1.1 mile (1.76 km) long beachfront community bounded by the Atlantic Ocean to the east and the Delaware Bay to the west. The Borough of West Cape May covers 1.2 square miles (3.1 km^2), and is located adjacent to The Meadows.

- ***Sediment Transport***

Andrews, Miller & Assoc., Inc., under contract to the Philadelphia District of the USACE, prepared an assessment of the longshore transport potential in the vicinity of Cape May Meadows and Cape May Point. The analysis was based on a near shore wave and current hindcast for the period 1987 through 1992. Wave induced sediment transport and current induced sediment transport were calculated separately across the study region. The rates were later combined and justified using shoreline evolution data. The investigation concluded that wave-induced longshore sediment transport is the dominant process in the Cape May area. The net direction of transport was from the east to the west at an average rate of 245,000 yd^3/yr (187,000 m^3/yr). The study indicated that current-induced sediment transport was not significant. However, sediment transport by tidal currents was limited to bed load only. In such a situation tidal currents scour the bottom and entrain sediment. Weak tidal currents are not efficient at suspending sediment, but can significantly influence sediment set in suspension by wave breaking and turbulence.

- ***Wave Environment***

Wave statistics pertinent to the study region are those derived for Station 67 of the WIS Report 30. Monthly mean wave heights for the entire 20 year hindcast range from 2.4 feet (0.73 m) in August to 4.3 feet (1.31 m) in December and January. The maximum reported wave height was 23.6 feet (7.19 m) with an associated peak period of 14 sec and a peak direction of 97° on March 7, 1962.

- ***Littoral Sediment Characteristics***

A composite beach grain size curve was developed for Lower Cape May Meadows and Cape May Point. The beach sand was finer in Cape May Meadows with a median diameter of 2.25 phi (0.21 mm). The median grain diameter for Cape May Point was 1.25 phi (0.42 mm).

2.3.1.2 Delaware Coast

Cape Henlopen-Fenwick Island

The Atlantic Coast of Delaware stretches from Cape Henlopen in the north to the southern border of Delaware with Maryland. The coast is 24 miles (38.6 km) of sandy shoreline which approximates a straight north-south orientation, and consists of six incorporated communities: Henlopen Acres, Rehoboth Beach, Dewey Beach, Bethany Beach, South Bethany, and Fenwick Island. The study area is separated midway by the Indian River Inlet. Rehoboth Beach is headland (+7 feet, 2.13 m -NGVD) that extends south for approximately 1 mile (1.6 km). The Silver Lake region, a 1000 foot (305 m) long headland, separates Rehoboth Beach from Dewey Beach. Dewey Beach is headland (+7 feet, 2.13 m -NGVD) approximately 1 mile (1.6 km) long with the southernmost 3000 feet (914 m) composed of barrier island. To the south of Dewey Beach is the unincorporated town of North Indian Beach, which extends to the Indian River Inlet. Bethany Beach is headland (+6 feet, 1.83 m -NGVD) extending for 1 mile (1.6 km) between the unincorporated towns of Sussex Shores to the north and Sea Colony to the south. South Bethany Beach is a barrier island (+6 feet, 1.83 m -NGVD) that extends south 1 mile (1.6 km) to Fenwick Island State Park.

- ***Sediment Transport***

At the northern end of the study area, the historic northward growth of the spit of Cape Henlopen is evidence of the predominant northward longshore transport. At Indian River Inlet, 13 miles (20.9 km) south of Cape Henlopen, sediment transport is also directed toward the north. This is supported by the long-term erosion and deposition patterns at the inlet jetties. At Ocean City (Maryland) Inlet, located 9 miles (14.5 km) south of Fenwick Island, littoral drift is toward the south. Deposition on the up-drift inlet jetty, and erosion on the down-drift beach (Assateague Island) is evidence of this southward predominance. In the reach between Indian River Inlet and Ocean City Inlet there is a nodal zone where littoral drift is diverging. The most recent analysis determined the gross sediment transport along the study region to range from 700,000 yd^3/yr (535,000 m^3/yr) to 900,000 yd^3/yr (688,000 m^3/yr) At Cape Henlopen the calculated net northward transport rate ranged between 150,000 yd^3/yr (115,000 m^3/yr) to 250,000 yd^3/yr (191,000 m^3/yr). At Indian River Inlet northward transport rates ranged from 75,000 yd^3/yr (57,000 m^3/yr) to 150,000 yd^3/yr (115,000 m^3/yr), and southward transport rates ranging from 125,000 yd^3/yr (96,000 m^3/yr) to 200,000 yd^3/yr (153,000 m^3/yr) were calculated along the southern border of Delaware with Maryland.

- ***Wave Environment***

Wave data for the study area was developed from the 20 year hindcast of general wave climatology presented in the USACE, WIS Report 30. The wave statistics found in the WIS Report 30 pertinent to the Delaware coast are for Stations 65 and 66. Waves approach the coast for the northeast and southeast quadrants, with the highest occurrence levels from the east and southeast directions. The largest significant wave height reported from the hindcast data was 25 feet (7.7 m) recorded during a March 1962 northeaster. Between 1992 and 1993 wave gages offshore of Dewey Beach recorded the highest wave height of 13.5 feet (4.1 m) during a December 1992 northeaster.

- ***Littoral Sediment Characteristics***

Composite beach grain size curves were developed for Dewey Beach, Rehoboth Beach, Bethany Beach, and South Bethany, using the USACE Automated Coastal Engineering System (ACES). Based on winter and summer beach composites in the study area, Dewey and Rehoboth beaches had a mean grain size of 1.82 phi (0.28 mm) with a standard deviation of 0.85 phi (0.23 mm), and Bethany Beach and South Bethany had a mean grain size of 1.81 phi (0.29 mm) with a standard deviation of 1.07 phi (0.48 mm). For all four beaches, this corresponds to poorly graded, or well sorted, fine to medium sands.

Ramsey (1999b) has recommended, based on more recent data, that sand placed on Delaware's Atlantic coast beaches should be in the coarse sand or coarse half of the medium sand range and should be well sorted or very well sorted. The sand should meet the following specifications: mean grain size 1.5 to 0.5 phi and sorting 0.5 or less phi.

2.3.1.3 Maryland Coast

Ocean City Maryland-Assateague Island, Virginia

The study area extends south 47 miles (75.6 km) along the Atlantic Coast, from the Maryland - Delaware border, through Maryland, and into Virginia. The Ocean City portion of Fenwick Island is 8.9 miles (14.3 km) in length from the Maryland - Delaware state line to Ocean City Inlet. Assateague Island is 37.8 miles (60.8 km) long, extending from Ocean City Inlet to Fishing Point, Virginia.

- ***Sediment Transport***

Average net longshore transport rates for this study area were computed over a 20 year period from 1956 through 1975. The net longshore transport at Ocean City ranged from 150,000 yd^3/yr (115,000 m^3/yr) to 300,000 yd^3/yr (230,000 m^3/yr) to the south. Assateague Island also showed a net southerly transport of 160,000 yd^3/yr (122,000 m^3/yr) with the exception of Fishermans point which had a net sediment transport rate of 24,000 yd^3/yr (18,000 m^3/yr) to the north.

- ***Wave Environment***

As of 1980, there was no recorded wave data for the Ocean City, Maryland Area. The data for the Atlantic City wave gage, which is located 70 miles north of the study area, was taken as being representative of the wave climate at Ocean City. The data indicates an average wave height of 2.7 feet (0.82 m) with a period of 8.2 seconds. Average storm conditions consisted of a wave height of 9 feet (2.74 m) and a period of 11 seconds.

- ***Littoral Sediment Characteristics***

The USACE (1980) reported that Ocean City sediments have a mean grain size of 2.02 phi (0.25 mm) with a standard deviation of 0.96 phi (0.51 mm), while Assateague Island has a mean grain size of 2.12 phi (0.23 mm) and a standard deviation of 0.54 phi (0.69 mm). According to more recent data reported by CERC (1990) for 396 grab-samples, values of 1.84 phi mean grain size and 1.22 phi sorting are more appropriate (see also Section 2.2.2.6).

2.3.1.4 Virginia Coast

Virginia Beach-Sandbridge

This segment extends from Cape Henry, VA through the Virginia-North Carolina state line. The most prominent physiographic feature in this area is the Chesapeake Bay, which was formed by the drowning of a large river valley as sea level rose at the end of the last Pleistocene glacial stage. Most of the coastline in the study area lies in the city of Virginia Beach, Virginia. The two major ocean beaches in this region which are separated by Rudee Inlet, are Virginia Beach and Sandbridge.

- ***Sediment Transport***

There are two predominant directions of littoral transport along the Atlantic shoreline of Virginia Beach. There is an annual littoral drift ranging from 104,000 yd^3 (79,500 m^3) to 215,000 yd^3 (164,000 m^3), directed toward the north from Cape Henry through Sandbridge. At False Cape, located two miles (3.2 km) north of the state line there is a divergence in longshore transport and littoral drift is primarily directed toward the south.

- ***Wave Environment***

Predominant wave directions that influence the Virginia Beach region range form northeast to east-southeast. The largest and most frequent waves impinging on the Chesapeake Bay entrance enter from the east-northeast and northeast from October - February. The Traverse Report of 1980 determined this shoreline is subjected to average wave conditions of moderate to high energy as classified by Dolan *et al.* (1975): Low waves - waves less than 5 ft (1.5 m) occur 20-29 percent of the time; moderate waves - waves greater than 5 ft (1.5 m) occur 30-39 percent of the time; and high waves - waves greater than 5 ft (1.5 m) occur 40-49 percent of the time. Only 13% of sand beaches and barrier island experience high energy conditions. Under the existing wave climate Virginia Beach is considered generally unstable and subject to extensive erosion. Hindcast statistics (Jensen 1983), for shallow water stations located offshore of Cape Henry predict waves to Virginia Beach are less than three feet (0.91 m) high more than 80 percent of the time. The calculated mean significant wave height was 1.8 feet (0.55 m), with maximum wave heights exceeding 17 feet (5.2 m).

- ***Littoral Sediment Characteristics***

The beaches are composed of quartzose sand, heavy minerals and shell fragments. The heavy mineral component reflects the composition of Pleistocene sediments. All of the beach sands belong are poorly graded and gravelly, with little or no fines. Foredune sand is usually finer and better sorted than elsewhere on the subaerial profile because of the selective action of the wind. Median grain diameters for the foreshore is consistently larger than mid-berm or dune sand throughout the study region. For Sandbridge the median grain diameter increases toward the north reaching a maximum of 0.64 phi (0.64 mm). All sand samples above the low water line have median grain diameters greater than 2.0 phi (0.25 mm). The task of determining native grain size characteristics has been made more difficult in Virginia Beach by the annual beach nourishment placed on the resort strip.

2.3.2 Biological Resources

While beach habitats have a lower diversity of organisms compared to other intertidal habitats, they are far from devoid of living organisms. Beach habitats are characterized by low-diversity biological communities of organisms which are either residents, specifically adapted to living in high energy, dynamic environments or are transients, feeding in the water column or on the sea floor as they migrate through an area (Hackney *et al.* 1996; Nelson 1985).

2.3.2.1 Benthos

Mole crabs (*Emerita talpoida*) and burrowing shrimp (*Callianassa atlantica*) are common inhabitants of the lower intertidal and subtidal beachface along with numerous smaller crustaceans, polychaete worms, and molluscs (Nelson 1985; Shelton and Roberston 1981). Ghost crabs (*Ocypode* spp.) occupy the upper beach. These semi-terrestrial crustaceans are highly mobile and are the only invertebrate species to leave the beach area during a nourishment event (Reilly and Bellis 1983). Indicator species, used to monitor the relative abundance and diversity of the benthic community of a beach also include the bivalve *Donax* spp. in the swash zone, ghost crabs in the supralittoral, and high beach amphipods (Orchestoidea and Talorchestia). Nelson (1985) lists the dominant invertebrate species found on sandy beaches from New England to North Carolina (Table 2-35). These species are adapted to the high energy and dynamic habitat of the surf zone and do not have to compete with many other species for space or resources. These species
are able to rapidly recolonize disturbed areas. While many species are found along the entire length of the Atlantic Coast of the U.S, the species composition of beaches changes from north to south as environmental conditions

vary.

The USACE, New York District monitored surf zone benthic invertebrate distributions along the coast of northern New Jersey from Manasquan Inlet to Asbury from 1994 – 1996 as part of their Biological Monitoring Program (BMP) (USACE-WES 1998). Mean abundance from three sampling stations was 13,721/m^2. Dominant taxa included Rhynchocoela (66% total abundance), the polychaete *Scolelepis squamata* (16% total abundance), and Oligochaeta (14% total abundance). Highest abundances of organisms occurred in spring samples compared to fall samples. Total biomass was dominated by annelids (73%), crustaceans (22%), and molluscs (19%). Annelid biomass was dominated by the polychaete *Scolelepis squamata*. Crustacean biomass was dominated by the mole crab *Emerita talpoida*. Total biomass was greatest in spring samples compared to fall samples. Sixty-nine taxa were collected during the study. Of these, 33 were polychaetes and 19 were amphipods. *Donax* sp. and haustoriid amphipods were conspicuously missing from the study as dominant surf zone taxa. The steep slope of the beachface was proposed as a possible explanation as to why these two taxa were not more abundant at these New Jersey beaches. It was suggested that a steep slope to the beachface would limit the area of available intertidal habitat that *Donax* sp. needs to forage and could potentially prevent the establishment of a large *Donax* sp. population.

2.3.2.2 Fish

Fishes associated with surf zones feed either in the water column or on the benthos. Lowest abundance and diversity of fish occurs during winter months and highest abundance and diversity occurs in late summer (USACE-WES 1998; Moyle and Cech 1982). The highest biomass of surfzone fish occurs in late fall when juvenile recruits are largest. The primary recruitment period is late spring to early summer and occurs later in the year than most estuarine environments (Hackney *et al.* 1996; Moyle and Cech 1982).

Almost all of the fish species utilizing beach habitats are transient species, foraging while passing through an area. Hackney *et al.* (1996) listed the ten most abundant species of fish caught on beaches in the South Atlantic Bight as: Atlantic menhaden, striped anchovy, bay anchovy, rough silverside, Atlantic silverside, Florida pompano, spot, Gulf kingfish, and striped mullet. Of these species only the Florida pompano and the Gulf kingfish use the surf zone as a nursery. While this study was not specific to the Mid-Atlantic Bight, the fish species collected can be found along the length of the Atlantic coast and are indicative of populations of fish using the surf zones in the study area.

The USACE, New York District monitored surf zone fish distributions along the coast of northern New Jersey from Manasquan Inlet to Asbury from 1994 – 1996 as part of their BMP (USACE-WES 1998). Results of the baseline study found 33 species of fish present in the surf zones of the beaches sampled. Dominant species included Atlantic silverside, rough silverside, bluefish, and striped anchovy. These 4 species accounted for over 99% of all fish caught in the three years of sampling. Greatest abundances were observed in August and September of each year. Species composition did not change dramatically during the sampling period. Species diversity, using the Shannon-Weiner Index (H’), was 0.785 (±0.009) for 1994, 0.768 (±0.010) for 1995, and 1.730 (±0.009) for 1996.

Table 2-35. Comparison of the dominant macrobenthic invertebrate species of exposed sand beaches of the northern U.S. Atlantic coast.

	New England (Croker et al. 1975; Croker, 1977)	**New Jersey** (McDermott 1983)	**North Carolina** (Matta 1977)	**North Carolina** (Leber 1982)
Intertidal				
	Acanthohaustorius millsi	*A. millsi*		
	Amphiporeia virginiana	*A. virginiana*	*A. virginiana*	*A. virginiana*
	Haustorius canadensis	*H. canadensis*	*Emerita talpoida*	*E. talpoida*
	Chiridotea caeca			
	Scololepis squamata	*S. squamata*	*S. squamata*	
		Donax variabilis	*D. variabilis*	*D. variabilis*
				Donax parvula
				Ocypode quadrata
Subtidal				
	A. millsi	*A. millsi*		*Ovalipes ocellatus*
	A. virginiana			*Areaeus cribarius*
	Bathyporeia quoddyensis		*B. quoddyensis*	
	Psammonyx nobilis			
	Manconcuma stillifera			
	S. squamata	*S. squamata*	*S. squamata*	
			Parahaustorius longimerus	
			D. variabilis	

Source: Nelson 1985.

2.3.2.3 Birds

Many species of seabirds, shorebirds and other types of birds may be found throughout the project area. A list of bird species that inhabit the mid-Atlantic region and that are likely to be found on or near beaches and other shoreline habitats is provided in Table 2-36. There are too many different species of this type to describe each of them in detail. Some of these species are beach-nesters, while others use onshore habitats for feeding and resting only. Beach-nesting birds may nest in colonies, as do gulls, terns, and skimmers, or as solitary nesters such as piping plover and American oystercatcher. A regional gradient
of nesting habitat scarcity for beach-nesting waterbirds exists on the Delmarva peninsula. Nesting habitat increases in abundance towards Virginia and conversely decreases northward through Maryland and

Table 2-36. Coastal and Pelagic Birds of the Mid-Atlantic Region

Common Name	Scientific Name	Habitat
American oystercatcher	*Haematopus palliatus*	sandy, mangrove, and gulf shores; bays and estuaries
bald eagle	*Haliaeetus leucogephalus*	coasts, lakes, rivers
black-legged kittiwake	*Rissa tridactyla*	rocky shores
black skimmer	*Rynchops niger*	rocky, sandy, & gulf shores, bays and estuaries
boat-tailed grackle	*Quiscalus major*	sandy and gulf shores, bays, estuaries, and salt marshes
brown pelican	*Palecanus occidentalis*	salt bays, beaches, ocean
double-crested cormorant	*Phalacrocorax auritus*	rocky, sandy, mangrove, and gulf shores; bays and estuaries
egret, great	*Casmerodius albus*	sandy and gulf shores, bays and estuaries, salt marshes
egret, snowy	*Egretta thula*	sandy and gulf shores, bays and estuaries, salt marshes
fish crow	*Corvus ossifragus*	sandy shores, bays and estuaries, salt marshes
gull, Bonaparte's	*Larus philadelphia*	sandy and gulf shores
gull, great black-backed	*Larus marinus*	rocky & sandy shores; bays and estuaries
gull, herring	*Larus argentatus*	rocky, sandy & gulf shores; bays and estuaries
gull, laughing	*Larus atricilla*	rocky, sandy & gulf shores; bays and estuaries
gull, ring-billed	*Larus delawarensis*	rocky, sandy, & gulf shores; bays and estuaries
heron, black crowned night	*Nycticorax nycticorax*	sandy and gulf shores, bays and estuaries, salt marshes
heron, great blue	*Ardea herodias*	sandy and gulf shores, bays and estuaries, salt marshes
heron, little blue	*Egretta caerulea*	sandy and gulf shores, bays and estuaries, salt marshes
horned lark	*Eremophila alpestris*	sandy shores
killdeer	*Charadrius vociferous*	sandy and gulf shores, bays and estuaries, salt marshes

Table 2-36 (continued). Coastal and Pelagic Birds of the Mid-Atlantic Region

Common Name	Scientific Name	Habitat
oldsquaw	*Clangula hyemalis*	rocky and sandy shores; bays and estuaries
osprey	*Pandion haliaetus*	sandy and gulf shores, bays and estuaries, salt marshes
peregrine falcon	*Falco peregrinus*	rocky and sandy shores
plover, black-bellied	*Pluvialis squatarola*	rocky, sandy, and gulf shores, bays, estuaries, salt marshes
plover, piping	*Charadrius melodus*	sandy shores
plover, semipalmated	*Charadrius semipalmatus*	sandy and gulf shores, bays and estuaries
plover, Wilson's	*Charadrius wilsonia*	beaches, tidal flats, sandy islands
red knot	*Calidrus canutis*	tidal flats and shores
ruddy turnstone	*Arenaria interpres*	rocky and gulf shores, bays and estuaries
sanderling	*Calidris alba*	sandy and gulf shores
sandpiper, least dunlin	*Calidrus alpina*	tidal flats and beaches
sandpiper, purple	*Calidris maritima*	rocky and sandy shores
sandpiper, spotted	*Actitis macularia*	rocky and sandy shores
scoter, black	*Melanitta nigra*	rocky and sandy shores; bays and estuaries
scoter, surf	*Melanitta perspicillata*	rocky and sandy shores; bays and estuaries
scoter, white-winged	*Melanitta fusca*	rocky and sandy shores; bays and estuaries
tern, common	*Sterna hirundo*	rocky, sandy, & gulf shores, bays and estuaries
tern, Forster's	*Sterna forsteri*	sandy and gulf shores
tern, least	*Sterna antillarum*	sandy & gulf shores, bays and estuaries, salt marshes
tern, roseate	*Sterna dougallii*	sandy and gulf shores
tern, royal	*Sterna maxima*	sandy & gulf shores, bays and estuaries
tern, sandwich	*Sterna sandvicensis*	coastal waters, jetties, beaches
whimbrel	*Numenius phaepus*	sandy shores, bays and estuaries
willet	*Catoptrophorus semipalmatus*	sandy and gulf shores, bays and estuaries, salt marshes

Sources: Amos and Amos 1985; National Breeding Bird Survey 1996.

Delaware (USACE 1998a). Barrier islands are important nesting habitats, such as Skimmer Isle in isle of Wight Bay (MD), and northern Assateague Island (USACE 1998a). Other types of birds in the region that do not use beaches and shores as their primary habitat, such as some waterfowl, wading birds, and songbirds, may also be encountered in the project area as flyovers or on the ocean surface at certain times of year. Threatened or endangered species are described in a separate section.

Common nesting species that utilize coastal habitat in the study area include the common tern, least tern, herring gull, laughing gull, and black skimmer. Brown pelicans are known to breed in Maryland and Virginia. Wading birds typically utilize the area from mid-March to mid-November before migrating south. Species include the snowy egret, great egret, and little blue heron. Many migratory species use the area for resting and feeding including the red knot, ruddy turnstone, sanderling, semipalmated plover, dunlin, least sandpiper, willet, and black-bellied plover.

2.3.2.4 Threatened and Endangered Species

Seven animal species and one plant species that may be found along beach/onshore coastal habitats in the mid-Atlantic region are listed as threatened or endangered under the Endangered Species Act. These are the northeastern beach tiger beetle (*Cicindela dorsalis dorsalis*), Puritan tiger beetle (*C. puritana*), piping plover (*Charadrius melodus*), roseate tern (*Sterna dougallii dougallii*), American peregrine falcon (*Falco peregrinus anatum*)* (see page 2-158), loggerhead turtle (*Caretta caretta*), and seabeach amaranth (*Amaranthus pumilus*). The loggerhead turtle, which is protected under the joint jurisdiction of the NMFS and USFWS, is described in Section 2.2.7.5 above. The remaining species are described below.

<u>Beach Tiger Beetles</u>

The northeastern beach tiger beetle and the Puritan tiger beetle are listed as threatened throughout their range. The USFWS lists the Puritan tiger beetle as a potential occurrence for Maryland, and the northeastern beach tiger beetle for New Jersey, Maryland, and Virginia. Both tiger beetles once ranged from Cape Cod, Massachusetts, south along the eastern seabord to the Chesapeake Bay. Today, the Puritan tiger beetle can be found on narrow beaches backed by cliffs in several Maryland locations including Calvert county and near the mouth of the Sassafras River in Kent and Cecil counties. The northeastern beach tiger beetle occurs on wider, sandy beaches in Calvert and Somerset counties in Maryland, and on both shorelines of the Chesapeake Bay in Virginia. In 1995, both new and second-year larvae of the northeastern beach tiger beetle were transplanted to Sandy Hook National Seashore component of the Gateway National Recreation Area in New Jersey (MacKay 1997).

<u>Piping Plover</u>

The piping plover is a small shorebird that was listed as endangered in the Great Lakes watershed and threatened throughout the remainder of its range on January 10, 1986. A revised recovery plan for the Atlantic coast population was issued in 1995. The USFWS lists the piping plover as a potential occurrence for all states within the project area. The piping plover breeds on the northern Great Plains, in the Great Lakes, and along the Atlantic coast from Newfoundland to North Carolina. They arrive at breeding areas in late March or early April, and depart for wintering areas in early September. Plover eggs hatch in July, but the chicks do not fledge until late August. Piping plovers nest above the high tide line on coastal beaches, sandflats at the end of sandspits and barrier islands, gently sloping foredunes, blowout areas behind primary dunes, sparsely vegetated dunes, and washover areas cut into or between dunes. Breeding territories include a feeding area, which include intertidal portions of ocean beaches, washover areas, mudflats, sandflats, wrack lines, and shorelines of coastal ponds, lagoons or saltmarshes (USFWS 1995a). Piping plovers winter on the Atlantic and Gulf of Mexico coasts from North Carolina to Mexico, and in the Bahamas. Wintering plovers along the Atlantic coast are generally found at accreting ends of barrier islands, along sandy peninsulas, and near coastal inlets. The population consisted of

1,350 pairs in 1995, up from 800 pairs when the species was listed in 1986. Since 1989, the New York-New Jersey subpopulation gained 62 pairs, and the Southern (DE-MD-VA-NC) subpopulation gained 18 pairs (USFWS 1995a).

Roseate Tern

The roseate tern is a seabird that was listed as threatened in the Caribbean part of its range, including parts of the U.S. (Florida, Puerto Rico, and Virgin Islands) and endangered in the northeast U.S. on November 2, 1987. The USFWS lists this species as a potential occurrence in New Jersey and Virginia. Currently about 6,000-6,500 roseate terns breed in an area from the south shore of Long Island north to Nova Scotia (NBS 1995). In the Caribbean, the roseate tern breeds from Florida through the West Indies to islands off Central America and northern South America. Roseate terns breed primarily on small offshore islands, rocks, cays, and islets. They almost always nest in colonies with common terns (*S. hirundo*) (NBS 1995). In contrast with common terns, which nest in open or exposed sites, roseate terns hide their nests under protective cover such as rocks, vegetation, or washed-up debris. If roseate terns are encountered in the project area, they would most likely be transients passing through the area during migration.

American Peregrine Falcon

The peregrine falcon is a medium-sized raptor that was listed as endangered throughout its range on June 2, 1970. The Arctic subspecies was downgraded to threatened status in 1984 and then removed from the list in 1994. In August of 1998, the USFWS proposed removing the American peregrine falcon from the endangered species list. On August 17, 1999, the American peregrine falcon (*Falco perigrinus anatum*) was officially delisted (50 CFR Part 17, as amended; Final Rule). Its removal from the Endangered Species List was publicly announced in the Federal Register on August 25, 1999 (64 FR 46542). The falcon is still protected under the Migratory Bird Treaty Act, and under the provisions of the Endangered Species Act, USFWS and the appropriate state wildlife agencies are required to monitor the status of the peregrine for the next 5 years. During this period, the status of the peregrine will be assessed to determine the necessity for relisting.

The USFWS lists the American peregrine falcon as a potential occurrence for all states within the study area. The historic range of the American peregrine falcon included the eastern U.S. from the Hudson Bay south to Georgia, an area from which the species was until recently considered extirpated. However, as a result of a captive breeding program instituted as part of the peregrine falcon recovery plan (USFWS 1987), more than 1100 peregrines have been reintroduced to the northeastern U.S. since 1974. It is now estimated that about 1593 breeding pairs inhabit the U.S. and Canada (USFWS 1998). In 1997, states within the project area reported 15 (NJ), 1 (DE), 11 (MD), 13 (VA), and 6 (NC) pairs of American peregrine falcons (USFWS 1997). Peregrines are found in coastal and estuarine regions, but cliffs or similar tall structures are necessary for nesting habitat. Such habitat is present in the Chesapeake Bay region.

Seabeach Amaranth

The seabeach amaranth is an annual plant found on Atlantic ocean beaches. The species is an effective sand binder, building dunes where it grows. Germination occurs over a relatively long period of time, generally from April to July. Flowering begins in June or July and seed production occurs from August through at least September. Under ideal conditions, the reproductive season can extend into January.

The seabeach amaranth is found on barrier island beaches, where its primary habitat consists of overwash flats at accreting ends of islands and lower foredunes and upper strands of noneroding beaches. It occasionally establishes small temporary populations in other habitats, including sound-side beaches, blowouts in foredunes, and sand and shell material placed as beach replenishment or dredge spoil. It does not occur on well-vegetated sites.

Historically, seabeach amaranth occurred in nine states from Massachusetts to South Carolina. It has been eliminated from five of the states in its historic range, including New Jersey, Delaware, and Virginia, and was listed as threatened on April 7, 1993. It is currently known from 13 populations in New York, 34 populations in North Carolina, and 8 populations in South Carolina. It was rediscovered on Assateague Island in 1998, near the north end. The only remaining large populations are in North Carolina, however, it is nearly absent from the northern third of the North Carolina coast. Only two plants were found north of Cape Hatteras in 1987 and 1988 (USFWS 1995b).

State-listed Species

In addition to the federally-listed threatened and endangered species described above, there are several species of concern listed in each state within the project area that may also inhabit beaches and onshore habitats. These are listed below.

New Jersey

State threatened and endangered species for this type of habitat are least tern (*Sterna antillarum*), black skimmer (*Rynchops niger*), and osprey (*Pandion haliaetus*).

Delaware

State threatened and endangered species for this type of habitat are bald eagle (*Haliaeetus leucocephalus*), which was recently removed from the federal list, and brown pelican (*Palecanus occidentalis*).

Maryland

State threatened and endangered species or species of concern for this type of habitat include Wilson's plover (*Charadrius wilsonia*) and American oystercatcher (*Haematopus palliatus*). State-listed plant species include: seabeach knotweed (*Polygonum glaucum*), whorled nutrush (*Scleria verticillata*); sea-purslane (*Sesuvium maritimum*); endangered extirpated salt-marsh spikerush (*Eleocharis halophila*); and threatened meadow lovegrall (*Eragrostis refracta*) (Lea 1998).

Virginia

State threatened, endangered, and species of concern for this habitat type are Wilson's plover (*Charadrius wilsonia*), brown pelican (*Palecanus occidentalis*), least tern (*Sterna antillarum*), Caspian tern (*Sterna caspia*), gull-billed tern (*Sterna nilotica*), sandwich tern (*Sterna sandvicensis*), and *Stygobromus araeus*, a tidewater interstitial amphipod.

2.3.3 Socioeconomic Environment

2.3.3.1 Recreation/Tourism

Recreational activities and tourism on the oceanfront beaches within the study area are critically important to the economies of the local coastal communities.

New Jersey has approximately 125 miles of shoreline extending from Sandy Hook to the north to Cape May to the south which contain popular tourist areas such as Long Beach Island, Wildwood, Atlantic City, and Cape May. Tourism plays a vital role in the state's economy accounting for approximately $10 billion dollars a year or over half of the state's total revenue.

Delaware contains approximately 24 miles of shoreline extending from Cape Henlopen to its border with Maryland at Fenwick Island. The ten beaches on Delaware's shore attract nearly 3 million visitors annually and contribute over $250 million each year to the state's economy.

Maryland has over 40 miles of shoreline extending from its border with Delaware to near the southern Assateague Island at the Virginia border. Ocean City is the largest tourist attraction on the Maryland shore. Assateague Island State and Federal parks also draw large numbers of visitors.

Virginia contains approximately 26 miles of oceanfront shoreline. The coast of Virginia is part of the extensive barrier island system of the Middle Atlantic states. North of Chesapeake Bay are broad wildlife refuge areas. South of the bay is Virginia Beach one of the Nation's largest coastal resorts. Virginia Beach attracts over 1.5 million tourists each year which generates approximately $300 million in revenue, with the local communities receiving over $10 million in taxes annually.

2.3.3.2 Archaeological and Cultural Resources

The replenishment of beaches with dredged sand is not expected to affect intact archaeological sites. Known archaeological sites along the Atlantic coast from New Jersey south to Virginia tend to be associated with lagoons and bays, which are low-energy environments, rather than open beaches, which are subject to tides, wave erosion, and storm damage and therefore not conductive environments for preserving archaeological remains. Very rarely, prehistoric archaeological remains are found washed up on beaches, out of their site context. Because these are mostly isolated finds whose origin cannot be determined, these artifacts have little research value. Although the likelihood is negligible, there is always the possibility that there are some deeply buried prehistoric sites in the beach areas that will be replenished; adding sand to these beaches will only aid in their preservation.

2.3.3.3 Infrastructure

The shoreline regions of the study area are speckled with an array of natural and man-made structures that are either visible year round or seasonally emergent based on winter storm erosion and sand movement. These coastal structures are engineered to provide shoreline protection, prevent or subdue erosional forces initiated by storms, allow for stormwater drainage, trap sand to create buffer zones between wave action and seaside development, or provide accessible areas for shoreline recreation. The more visible shorefront structures observable year round include recreational fishing piers, seawalls, bulkheads, jetties, groins, stormwater outfalls, boardwalks, and lighthouses. Some of these structures are partly inundated by tidal fluctuations (jetties, outfalls, etc.) and may extend farther offshore than visibly apparent. Local submarine cables and pipelines are also apparent throughout the study area but, a majority of these structures connect the mainland to the appropriate barrier island in backbay localities and are usually not present in areas where beach replenishment operations will commence. Structures that are exposed during the winter months, yet not necessarily apparent during the calmer months of the year include pile fields created from previous structures, riprap, previous boardwalks (Atlantic City, New Jersey), and once covered shipwrecks. Natural sand ridges are also present and tend to migrate seasonally inshore and offshore based on storm factors and natural beach processes.

3.0 POTENTIAL ENVIRONMENTAL IMPACTS OF OFFSHORE DREDGING AND BEACH NOURISHMENT

3.1 Introduction

The following chapter is divided into a discussion of the potential impacts to environmental resources and processes from dredging offshore and the placement of the dredged sand onto beaches within the study area. As reported in numerous USACE studies and NEPA documents for beach nourishment projects within the study area, the dredging operation will cause direct impacts to the physical environment and biological resources within the dredged area due to changes in bottom topography and habitat. The dredging operation will remove sediment and any benthic organisms that are living within (infauna) and on the sediment (epifauna). It will also result in the deposition of disturbed sediment over undisturbed portions of the seabed and dispersion of particulate matter throughout the water column.

3.2 Future Requirements for Sand

MMS requested an estimate of the potential future state needs for federal offshore sand. The State of Delaware (April 23, 1999) stated that together with the USACE they developed an estimate of 23 million cubic yards of sand for the 50-year duration of proposed federal beach protection projects (Appendix D). They indicated that identified borrow sites within the three-mile limit may not be adequate to meet demands. The State of Virginia (January 29, 1999) stated that yearly maintenance and future enhancement projects are planned for approximately 24.5 miles of public beach in Hampton, Norfolk, and Virginia Beach and that identification of suitable Federal sources is a priority (Appendix D). The State of New Jersey (May 5, 1999) indicated that it is interested in federal offshore resources as a contingency to its Shore Protection program.

3.3 Continental Shelf

3.3.1 Dredging/Extraction Methods

3.3.1.1 Introduction

This section reviews the dredging extraction methods that may be applied in beach nourishment projects utilizing sand resources in the Federal OCS. Dredges are grouped into two main classes: mechanically operated and hydraulically operated (Herbich 1992). With respect to a site specific project, each type of dredge has its advantages and disadvantages. Offshore sand mining projects employ the hydraulic type almost exclusively. Therefore, the following discussion focuses on hydraulic dredges.

Together with other factors (including practicality and costs), the distance from borrow site to beach determines the dredging and sand transport method to be used. Two methods are commonly used: (1) a hydraulic cutter suction dredge which pumps the material as a fluidized mass (slurry) through a pipeline deployed on the seabed, for placement and discharge onto the beach, or (2) a hopper dredge, equipped with two dredgeheads and a hopper. When the hopper is full, the dredge transports the collected sand to the shore for unloading via an offshore pumpout shoreline connection, and subsequent placement on the beach.

Generally, if the borrow area is less than 5-6 km from the beach, then cutter suction and pipeline are used. If the distance is greater than 5-6 km, a hopper dredge is employed. Pipeline deployment over greater distances is possible, but is dependent upon the prevailing sea conditions at the site. A cutter suction dredge is more productive than a large hopper dredge because the latter cannot approach close to the beach with the prevailing water depths.

3.3.1.2 Hydraulic Dredges

Most modern, high capacity dredges are of the hydraulic type employing suction produced by high speed centrifugal pumps to excavate the sediment and dispose of it, either through a pipeline or to a storage hopper. Material dislodged from the ocean floor by the suction is suspended in water in the form of a slurry and then passed through the centrifugal pump and discharge pipeline to the nourishment or disposal site. The types of dredges likely to be used in obtaining offshore sand for beach nourishment projects are: cutterhead and hopper dredges. Hydraulic dredges have very high production rates when the materials to be dredged are relatively soft and contain a high ratio of water.

3.3.1.2.1 Cutter-Suction Dredge

The cutter-suction dredge is the most widely used dredge in the industry. It is equipped with a rotating cutter which surrounds the intake end of the suction pipe (Figure 3-1). It can efficiently excavate all types of compacted sediments such as dense sands, gravel, clay and soft rock. The cutter-suction dredge is primarily used in beach nourishment projects and navigation channel dredging.

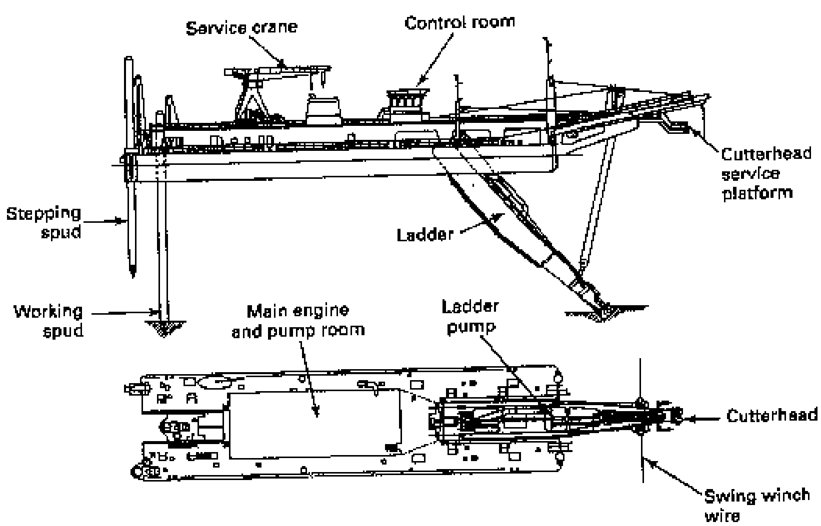


Figure 3-1. Main features of cutter suction dredgers.

Herbich (1992) enumerated the requirements for a seagoing cutterhead dredge:

1. An offshore dredge must be capable of operation in open seas. This requires a minimum motion response to waves and high maneuverability and control. An offshore dredge which can operate safely and efficiently in seas with a wave height of 6.6 ft (2 m) would establish a 95 percent on-the-job record along the continental United States coasts.
2. Since an offshore dredge must move frequently from site to site, it must have high mobility and low drag during transit.
3. It should be able to dig to a great depth, say, up to 100 ft (30.5 m). Since the maximum depth that a dredge can dig is limited by the barometric pressure, this would require a pump being installed well below the ocean surface.
4. It should have a high operating efficiency, low costs, and a large capacity of 2000 yd^3/hr (1529 m^3/hr) or

higher.

The cutter suction dredge is usually rated according to either the diameter of the discharge pipe, which may range from 6” to 36” or by the power of the cutterhead which may range from 15 Kilowatts (27 HP) to 4500 Kilowatts (8000 HP).

Method of Operation (Beach Nourishment)
The soil or rock to be dredged is cut or dislodged by a rotating crown cutter. The cutter typically has five or six plain or toothed blades designed according to the type of soil conditions encountered (Figure 3-2). The cutterhead is either electrically or hydraulically driven by a cutter motor mounted directly behind the cutter at the extremity of the dredge ladder or by an inboard motor connected to the cutter by a long drive shaft. The cutterhead encloses a suction intake pipe of a centrifugal dredge pump. The pump may be either inboard or, in cases of dredges with very long ladders for deep digging or for working in deep water, mounted at the extremity of the ladder.

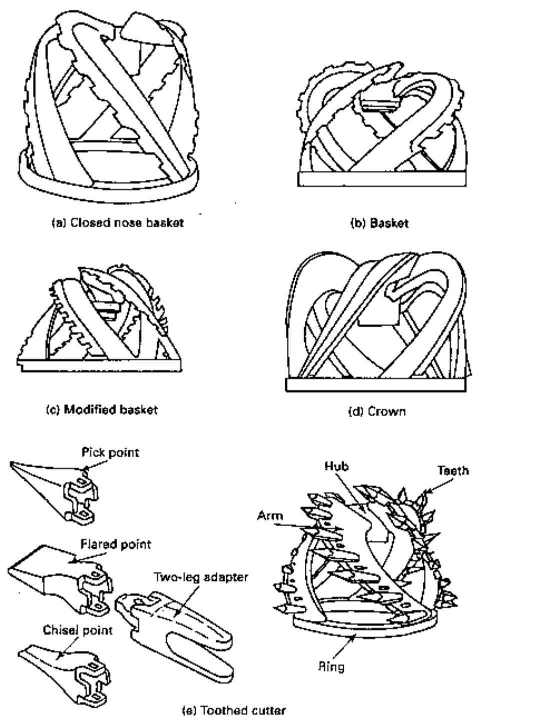


Figure 3-2. Examples of cutterheads for cutter suction dredges.

The ladder is attached to the main hull by hinges that permit rotation of the ladder in a vertical direction. The ladder is raised and lowered by means of a hoisting winch controlled from the bridge. Alternatively, on some small dredges, the ladder movement may be controlled by hydraulic cylinders.

The main pontoon contains the dredge pumps, main engines and any ancillary engines and drives. Small dredges are generally diesel-hydraulic while the larger dredges are diesel-electric.

A typical 30 inch dredge designed for beach renourishment has 5000 to 8000 HP on the dredge pump and 2000 HP on the cutter and will pump 2000 to 4500 yds^3/hr of average density sand material through pipeline lengths up to 15,000 feet. The dredge is generally equipped with two stern spuds which are used in combination with head anchors and winches to advance the dredge into the cut or excavating area. When dredging, the working spud is “spudded in” to the seabed. The underside of the cutter is maintained at a level just below the desired finish level and rotated across the arc-shaped face by hauling in on one head anchor line while paying out the other head anchor lines (warping). When a large depth of material is to be removed, several cuts across a face may be necessary to reach the desired depth. In loose material, the depth of cut may be several times the diameter of the cutter. In harder material, stiff clay or rock, the depth of the cut is usually less than the diameter of the cutterhead. Cutterhead diameters are typically 3 – 4 times the diameter of the suction pipe.

Discharge and Pipeline Conveyance
The discharge from the dredge pump passes over the stern to a hose or flexible coupling which is connected to a floating pipeline which, in turn, is connected to an onshore pipeline. Pipelines to the shore are most commonly of steel construction in pipe lengths of 40 feet connected with steel ball joints or rubber sleeve flexible joints. The pipeline may be a floating pipe or consist of sections mounted on steel pontoons for floatation. In offshore environments, a submerged pipeline may be substituted for the floating line. Often a combination of the two methods is employed, a floating line from the dredge to an offshore barge anchored at a central point and a submarine pipeline from the moored barge to the discharge point on the beach. Often the floating transfer barge contains a booster pump in order to maintain flow over long distances.

Limiting Environmental Factors for Cutter Suction Dredges
The following is a summary of average environmental limits for economic cutter suction dredging operations based on the size and characteristics of currently available equipment.

Max. Water Depth to Dredge	100 ft
Max. Cut Width	575 ft
Max. Ocean Wave Height	6.5 ft
Max. Swell Height	3.3 ft
Max. Cross Currents	2.0 kn

3.3.1.2.2 Trailer Suction Hopper (TSH) Dredge

Trailer suction hopper (TSH) dredges are self-propelled ships suitable for operations in an ocean environment and capable of mining sand and loading a self-contained hopper while the ship is underway (Figure 3-3). Most trailer suction hopper dredges are twin screw and have bow thrusters which provide a high degree of maneuverability. Loading takes place as the ship moves ahead at a speed of 2-3 knots. Unloading can be by bottom discharge (bottom doors or split hull), pump discharge, or discharge by mechanical means (dragging, grab, etc.). TSH dredges, while mainly used offshore for aggregate mining, are frequently employed on beach nourishment projects, especially where the distance of the borrow area to the shore is a factor.

The main advantages of the TSH are:

- performance in high sea state conditions with the use of heave compensated drag arms;
- independent operation without tender vessels;
- the ability to transport materials over long distance;
- the high rate of production; and
- operation in relatively deep water.

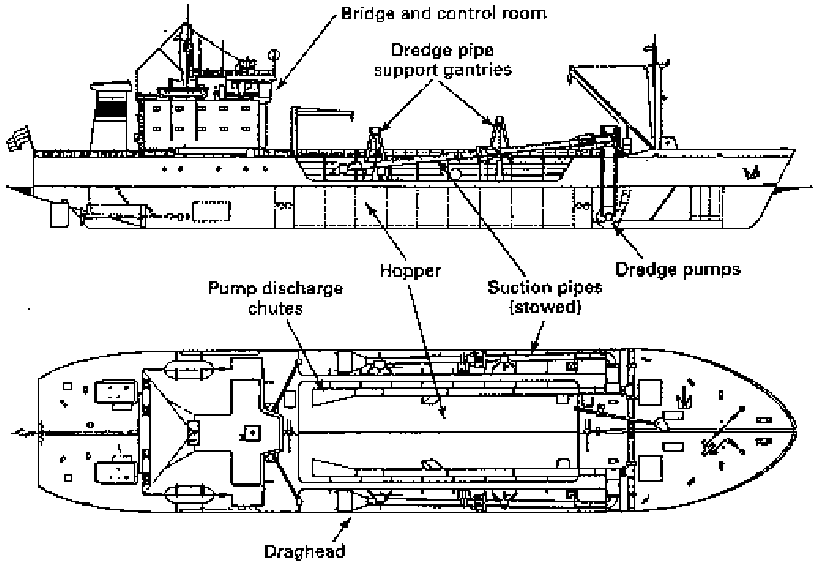


Figure 3-3. Main features of trailing suction hopper dredgers.

The TSH dredge is normally rated according to its maximum hopper capacity, typically in the range of 1,000 cu yds to 20,000 cu yds. The world's largest TSH, "Queen of the Netherlands," commissioned in 1998, has a hopper capacity of 30,350 cu yds.

TSH dredges are normally self-propelled ships that can travel between sites under their own power. A large proportion of the internal space of the TSH is occupied by the hopper space into which the material is loaded by one or two large centrifugal pumps. The pumps are usually inboard but may not be fitted into the trailing suction pipe (submerged pump). Submerged pumps are a necessity for all deep water dredges. The suction pipe is stowed inboard when the ship is in transit between the dredging site and the discharge or off loading site (Figure 3-4).

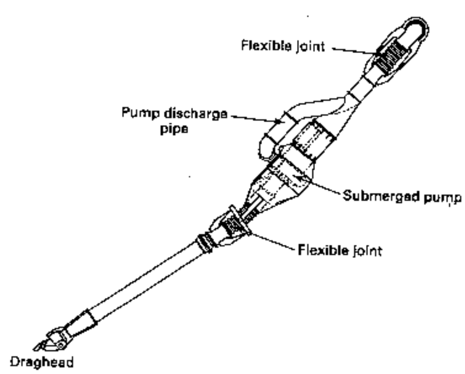


Figure 3-4. Suction pipe of trailing suction hopper dredger, fitted with submerged pipe.

Maximum Operating Depth

The maximum operating depth to which a hydraulic dredge can operate is limited by the vacuum head generated by the dredge pump. If the pump is mounted within the hull of the vessel, the maximum economical dredging depth is about 100 feet. By mounting the dredge pump externally in the trailing suction pipe, close to the draghead, a much greater depth may be achieved along with improved production. Dredging production from 400 feet depth is now achievable economically. Figure 3-5 shows the relationship of dredging depth to pump power for TSH dredgers.

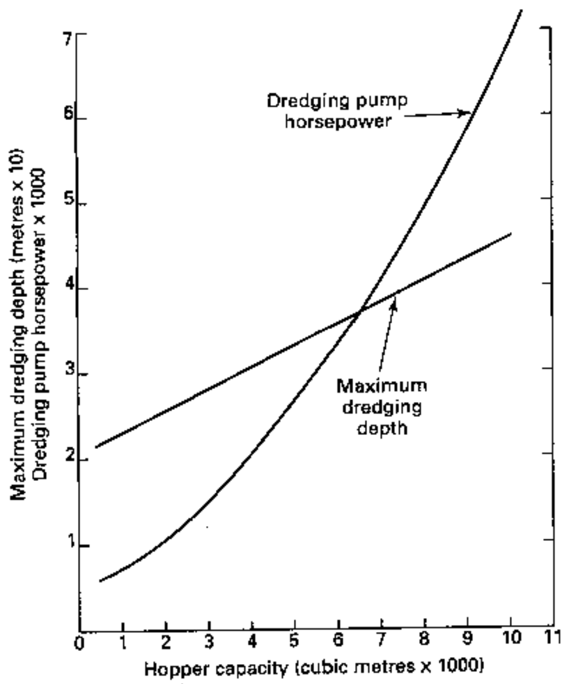
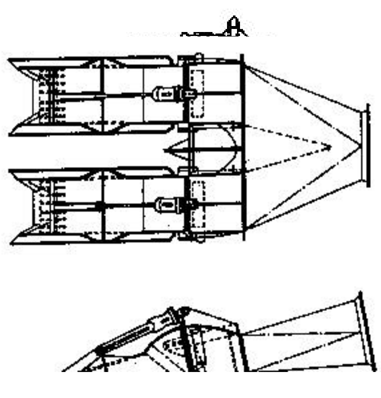


Figure 3-5. Maximum dredging depth and pump power for TSH dredges.

Dredging Procedures

The trailer suction pipe with draghead attached is swung outboard and lowered by means of winches and davits. If inboard pumps are installed, the inboard end of the suction pipe is lowered in a fixed track to mate, below the waterline, with the pump suction intake which is open in the side of the hull. Pipe works from the discharge side are routed to the hopper where discharge is conveyed to launders (chutes) to minimize turbulence. If the dredging pumps are located within the trailing suction pipe then there is a fixed connection of suction and pressure pipe systems.

The intake end of the suction pipe is fitted with a draghead, the function of which is to strip off a layer of sediment from the seabed and entrain those sediments into the suction pipe. The draghead is lowered from the vessel proceeding forward at a speed from 1 to 5 knots. Examples of various dragheads are shown in Figures 3-6a-f. The bearing pressure of the draghead on the seabed is controlled by an adjustable pressure compensator system which acts between the draghead and the hoisting winch which supports the trailing pipe. This same system acts as a heave compensator that accumulates and smooths out the vertical forces resulting from induced wave motions of the dredge. Because of this heave compensation, the TSH can dredge effectively in sea states much higher than those which would limit the effectiveness of a cutter-suction dredge.



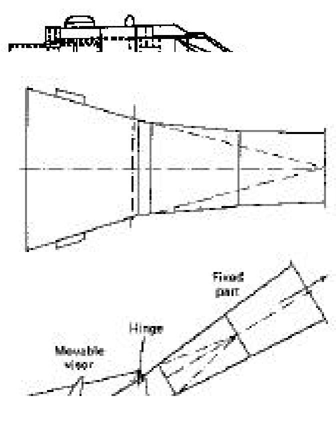
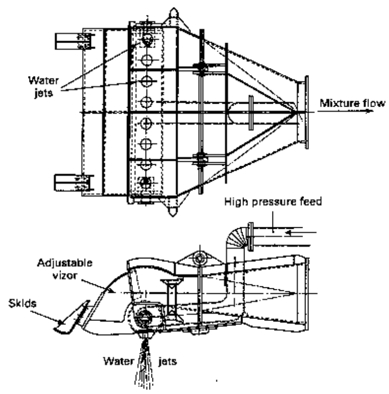


Figure 3- ad. Figure 3-6

Figure 3-6c. Example of Californian draghead.

Figure 3-6d. Example of Venturi draghead.



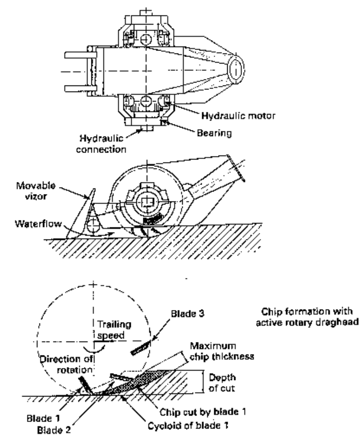


Figure 3-6e. Example of draghead fitted with water jets.

Figure 3-6f. Example of active draghead.

In soft sediments, the entrapment of soils from the seabed into the suction pipe is produced mainly by the erosive action of the fluid flow produced by the suction action. In denser material, dislodgment of the seabed material is assisted by the rotating action of the scrapers and knife edges of the dragheads. For very firm material, dislodgment may be assisted by the use of high pressure water jets. The various types of dragheads form distinct trenches on the seafloor surface (Figure 3-7). The general application of the various dragheads in specific sediment types is provided in Table 3-1.

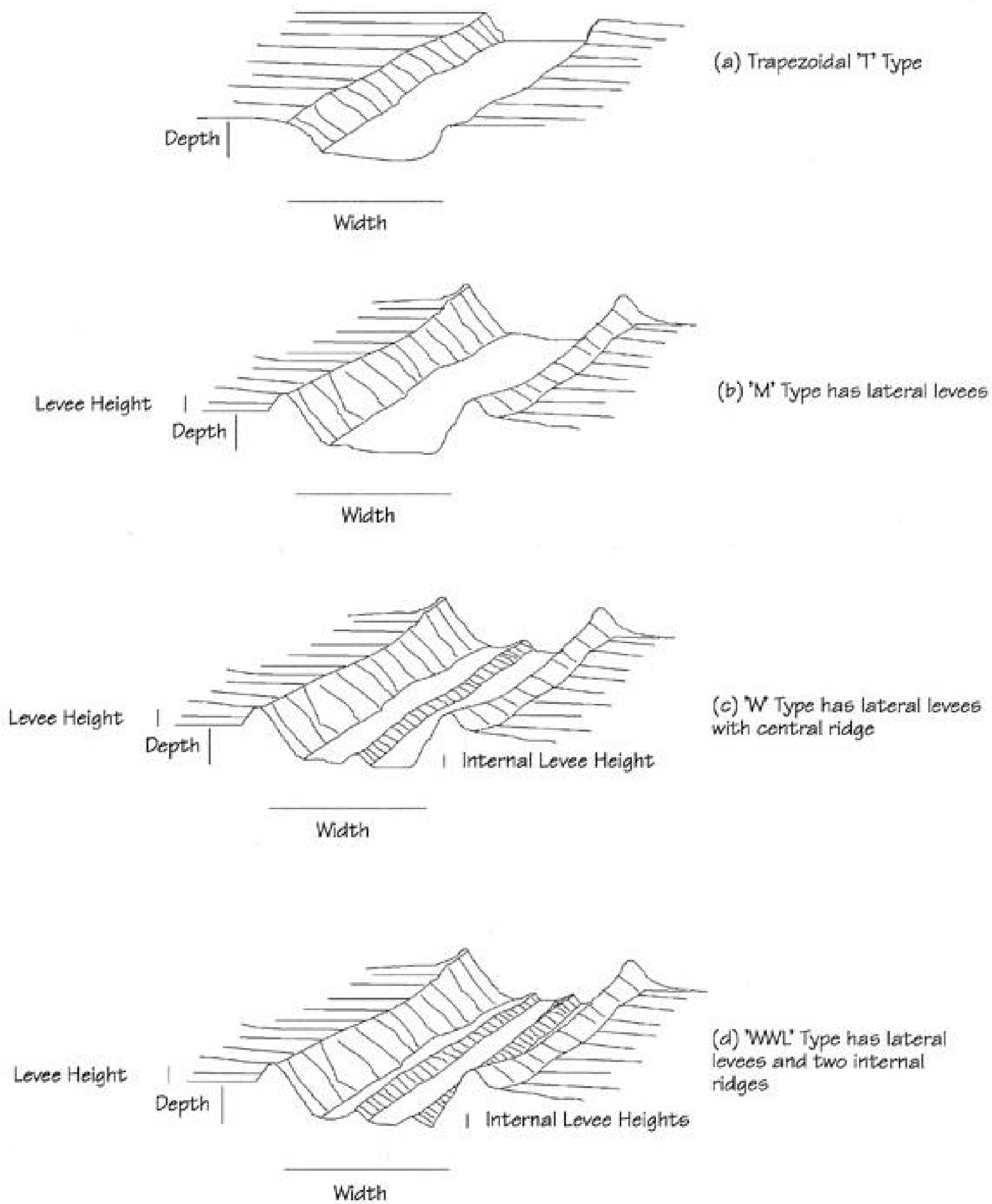


Figure 3-7. Primary seabed furrow characteristics formed by dragheads commonly used for aggregate dredging in the United Kingdom (from Hitchcock *et al.* 1998).

Table 3-1. Various Types of draghead and their common application.

Type	General Application	Figure
Fruhling	Silts, soft clays and loose sands	3-6a
Silt	Silts	3-6b

Californian	Sands, especially compact sands	3-6c
Venturi	Sands	3-6d
Waterjet	Firm sands and medium clays	3-6e
Active	Medium, firm and stiff clays	3-6f

The trailer suction pipes are usually articulated along port of the barge by means of an articulated link which supports a hose connection between adjoining lengths of rigid pipe. This articulation permits relative movement between the draghead and the vessel. As the vessel pumping continues, the sediment particles settle in the hoppers and the excess water passes overboard through overflow troughs. The volume ratio of solids to water is generally around 15-20 percent. To reduce surface turbulence, overflow water is conducted along weirs and conveyed along the sides of the dredges opposite to where the dredged material is discharged into the hopper. In addition, to help reduce the effect of a surface plume the overflow is conveyed down along the side of the vessel hull to discharge below the waterline. This allows sufficient time for the particles to settle before overflowing.

Loading Time
The loading times of TSH dredges are highly variable and are dependent upon the physical characteristics of the material being dredged, the mechanical properties and efficiency of the dredging plant and vessel, and the sea state conditions under which the dredging takes place. With coarse material that has a fast settling rate, long overflow times will be required to fill the hoppers to capacity. These times diminish as the particle size becomes smaller because a greater proportion of the solids remain in suspension, causing the density of overflow mixture to be very nearly the same as the density of the mixture being delivered to the hopper. For coarse grained sands and gravels, the dredging rates are much slower than fine-grained sands and gravels, overflow discharges are relatively clean and dredging can take up to 1–2 hours to reach hopper capacity.

Limiting Environmental Factors for Trailer Suction Hopper Dredges
The limitations affecting when and where trailers can operate will vary according to the size and characteristics of the particular dredger, but an indication of the extreme limits which will apply to economic operation is given below. These limits apply respectively to the smallest (minimum) and largest (maximum) of this type of dredger in common use.

Minimum water depth to operate	15 feet
Maximum water depth to operate	150 feet (very few to 300 feet)
Maximum sailing speed	17 knots
Minimum turning circle	250 feet
Maximum wave height	15 feet
Maximum cross current	3 knots
Maximum particle size	300 millimeters

Hopper Discharge
Hoppers may be discharged (unloaded) in a number of different ways. For beach nourishment projects, material is typically pumped through an on-board pump to a shorepipe or directly ashore.

3.3.1.3 Innovative Techniques

3.3.1.3.1 Punaise

Most advances in the dredging industry are modifications to existing equipment. Infrequently, a new dredging concept is developed. One such innovation in the past 7 years is the "Punaise" (Dutch for thumb-tack) dredging system designed and constructed by De Groot Nijkerk Machinefabriek and J.G. Nelis Group of the Netherlands (Brouwer *et al.* 1991; Brouwer *et al.* 1995). The Punaise is a remotely operated, water tight submerged dredge that resides on the seafloor and pumps sediment without impact to navigation. Because it is located on the seafloor, it is not affected by adverse surface wave action allowing it to operate in all types of weather and sea state conditions. The Punaise is connected to a shore station via an umbilical which serves not only as the communication connection, but also as the discharge line through which the dredge slurry is pumped. The entire dredging process, including sinking and floating (i.e. filling and emptying ballast tanks), is controlled from the shore station by one individual. The Punaise can thus operate for long periods with relatively low labor costs. Maximum flexibility in sediment removal is attained through the flexibility of repositioning the Punaise at the dredging site from time to time with the help of a tug. Punaise production depends on both the sediment grain size and the pumping distance.

The Punaise operates under the principle of the deep dredging process (i.e., putting the dredge pump as close to the sediment intake as possible). In so doing, the Punaise requires embedded support that must extend below the suction intake for vertical stability during dredging. The Punaise contains a dredge pump, electric motor, instrumentation, suction intake and vertical support. Specifics for two Punaise models are provided in Table 3-2.

During setup prior to dredging, the shore station is established and the umbilical is floated to the dredging site. The Punaise is then connected to the umbilical and positioned at the appropriate location for sinking to the seafloor. Once positioned, the ballast tanks are filled and the Punaise settles to the bottom. Fluidizers are then activated which allow the vertical support (best described as an extension of the suction pipe) to settle into the sand bottom. When the suction intake reaches the level bottom, dredging begins. As material is removed, a crater or pit is formed with the Punaise located at the lowest point. Dredging continues and the crater/pit grows in size (Punaise settles further into bottom) until either the desired dredging depth is reached or resistant bottom features (bedrock, clay, etc.) prevent further settling.

3.3.2 Physical Environment

3.3.2.1 Geology

Introduction

Geologic setting plays a multiple and long-reaching role in any project to dredge offshore sands for beach nourishment. Existing geological conditions place practical constraints on the implementation of the action, and the action itself will have numerous impacts on existing geologic processes and conditions. These impacts, in turn, have a potential to affect biological and physical processes onshore and offshore.

The siting of the dredging operation is controlled by existing geological conditions, i.e., the location of the geomorphic features and geologic structures with available and suitable sand reserves. The geologic conditions at a chosen borrow site will place constraints on the methodologies used to recover sand. The chosen methods, in turn, will impose method-specific environmental impacts and affect the cost of recovery.

Table 3-2. Punaise Specifications

	PN250		PN400	
	SI	English	SI	English
Width	7.8 m	25.6 ft	8.5 m	27.9 ft

Height (without suction pipe) Height (with suction pipe)	3.1 m 8.5 m	10.2 ft 27.9 ft	6.0 m 8.7 m	19.7 ft 28.5 ft
Draft	7.5 m	24.6 ft	6.5 m	21.3 ft
Working Depth	30 m	98 ft	40 m	131 ft
Required sediment thickness Initial Production Max. Production	6.0 m 8.0 m	19.7 ft 26.2 ft	7.0 m 10.0 m	23.0 ft 32.8 ft
Pump Capacity	800 m^3/hr @ 6 bar	1,046 y^3/hr @ 87 psi	2,400 m^3/hr @ 8 bar	3,140 y^3/hr @ 116 psi
Discharge Pipe Diameter	26.0 cm	10.2 in	40.0 cm	15.7 in
Weight/Mass	47 m-tons	52 tons	95 m-tons	105 tons

Potential onshore impacts of offshore dredging in Federal waters include the impact of nourishment using sands that are too fine or too coarse and the impact of altered offshore current patterns that affect onshore wave energy and sediment transport. The potential offshore impacts of dredging on the continental shelf concern the effect of altering the sedimentary environment at the borrow site. These impacts are discussed below.

Changes in Bathymetry

Dredging for sand will change the existing bathymetry at the borrow site. Dredging at a shoal may result in the total removal of this topographic feature. A bathymetric depression or pit may also result. If select areas of the shoal are dredged (*e.g.*, the crest), there will be an increase in the depth of the water column over these areas. Dredging of a relatively flat sand sheet would leave a pit or trench (Figure 3-8). Dredging to remove subsurface channel sands would also leave a pit on the sea floor.

Each of these changes will affect current patterns at the site. The manner in which current patterns could be modified are discussed in Section 3.3.2.3. Changes in existing current strengths and directions will, in turn, alter depositional patterns. Water movement in a pit may be reduced and lead to the development of anoxic conditions. The impacts of these changes to local water chemistry and biological resources are discussed in Sections 3.3.2.4 and 3.3.3, respectively. Diminished current velocities over a pit may promote the deposition of fine sediments. If the sediment supply is not sufficient to fill up the pit with either sand or fines, it will persist. On the other hand, changes in currents may result in the scour of pits and the removal of fine sediments.

Altered Bottom Substrate

The bottom substrate at and near a borrow site may be modified in several ways. As discussed above, a change in the hydrologic regime as a consequence of altered bathymetry may result in the deposition of fine sediments where there had been a shifting sand sheet environment.

TRAILER DREDGING

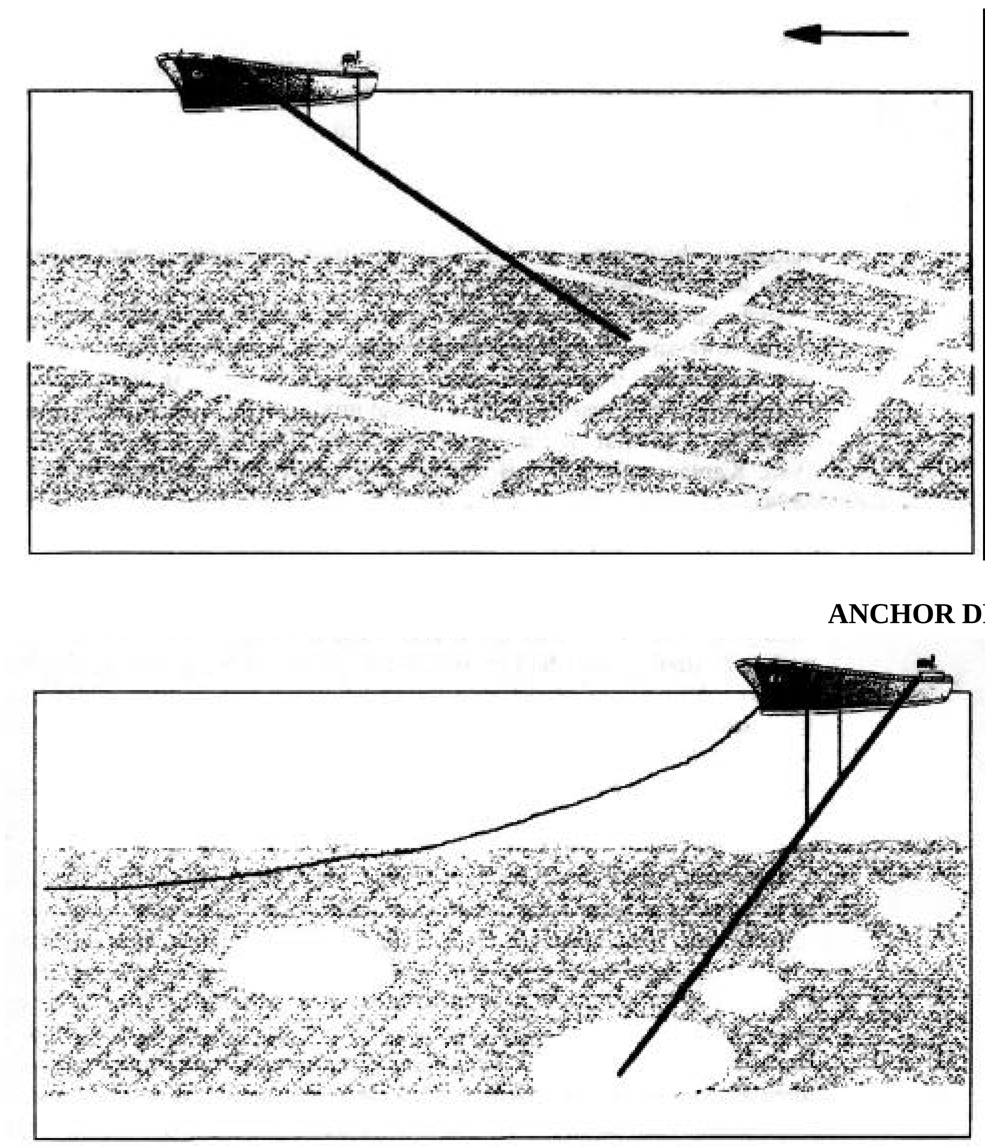


Figure 3-8. Diagram showing the two principal methods of dredging for marine aggregates in European coastal waters. Upper diagram shows the furrows left on the sea bed by trailer suction dredging while the vessel is under way. In this case, the sea bed is crossed by a series of tracks which are 2-3 m wide and up to 50 cm deep. Lower diagram shows the pits left on the sea bed by anchor dredging. In this case the vessel is anchored and the dredged pits may vary in dimension based on the time spent on a site (from Newell *et al.* 1998a).

Existing substrate characteristics may also be changed by the exposure of underlying sedimentary units. The removal of surficial or subsurface sand units may expose underlying material that has different textural and compositional properties than the existing surface substrate. The most drastic change would be from sand to mud. The impact of a substrate change to biological resources is discussed in Section 3.3.3.2.

The bottom substrate at a distance from the borrow site will also be modified by the deposition of sediments in benthic and surface plumes generated by dredging activities. Sediments contained within plumes produced from the disturbance and resuspension of bottom sediments, and from discharges of the dredging vessel and equipment, will settle out from the water column and be deposited at a distance from the dredge site. The resedimentation of resuspended sediments may result in a layer of sediment that differs from the existing substrate. The impact of plumes to water column chemistry and biological resources is discussed in Sections 3.3.2.4 and 3.3.3, respectively.

3.3.2.2 Air Quality

Air quality impacts of a proposed project within the study area would come from operation of the dredge pumps, the pump-out equipment, the dredge propulsion engines, tugs and barges, and heavy equipment utilized on the beach. Since the project is located along the East coast of the U.S., winds often blow offshore; there are periods in the summer and fall when winds are light and relatively high air pollutant concentrations can occur over a wide area.

Sources of Air Quality Impacts

The main sources of proposed project air quality impacts are the air pollutants emissions resulting from dredging operations by utilizing heavy equipment in the specific area and at the beach over an extended period of time. The type of dredging activities and equipments used that induce air emissions vary by the dredging methods. Two typical methods would be used for the proposed project: (1) a TSH dredge, equipped with twin drag-heads and a hopper, or (2) an hydraulic cutter-suction dredge anchored at the borrow site pumping the materials ashore through a pipeline deployed on the seabed. In both operations, the critical air emissions are in the form of nitrogen oxides (NO_x), with smaller amounts of SO_2, VOC, CO and PM.

When a hopper dredge is used, air emissions would result from the diesel engines used for the operation of the pumps during the dredging, propulsion as the dredge moves from the excavation site to the discharge site, and the pump-out at the pipeline near the beach. In addition, the emissions resulting from the operation of tugboats and barges for relocating the mooring buoys, from auxiliary power and engine idle, and on shore pollutants generated by those bulldozers and trucks engaged in beach filling and grading operations need to be evaluated as well.

When a cutter-suction dredge is used, the dredge stays around the excavation site and the excavated material is transported directly to the beach as a slurry in a pipeline. While the emission characteristics are similar to those emissions associated with a hopper dredge, over water air emissions generally occur at a farther distance from shore.

Project Conformity Determination and Emission Thresholds

Section 176(c) of the Clean Air Act, as amended in 1990 requires federally sponsored or approved project to perform a conformity determination, which is defined as conformity to the SIP's purpose of eliminating or reducing the severity and number of violations of the NAAQSs and achieving expeditious attainment of those standards, as indicated in the U.S. EPA developed "Determining Conformity of General Federal Actions to State or Federal Implementation Plans; Final Rule" (40 CFR Parts 6, 51 and 93). In the final rule, the emission thresholds are established, any project resulting emissions exceeding the thresholds have to follow all procedures and guidelines described in this rule for conformity determination. For a project site within a severe nonattainment area, the threshold is 25 tons/year for NO_x and VOC. For a project site locates at a moderate or marginal nonattainment area within an Ozone Transport Region, the threshold is 100 tons/year for NO_x and 50 tons/year for VOC. The emission thresholds for the most critical project pollutant NO_x within various project impacted areas are outlined below.

Project Site Location	**EPA Designation**	**NO_x Emssion Threshold (tons/year) for General**

(State, County)		for O_3	Conformity Determination
New Jersey	Monmouth	Nonattainment (Severe-17)	25
New Jersey	Ocean	Nonattainment (Severe-17)	25
New Jersey	Burlington	Nonattainment (Severe-15)	25
New Jersey	Atlantic	1-hour O_3 standard no longer applies (previously designated as Moderate Nonattainment)	N.A.
New Jersey	Cape May	1-hour O_3 standard no longer applies (previously designated as Moderate Nonattainment)	N.A.
Delaware	Kent	Nonattainment (Severe-15)	25
Delaware	Sussex	1-hour O_3 standard no longer applies (previously designated as Marginal Nonattainment)	N.A.
Maryland	Worcester	Attainment	N.A.
Maryland	Wicomico	Attainment	N.A.
Maryland	Somerset	Attainment	N.A.
Virginia	Accomack	Attainment	N.A.
Virginia	Northampton	Attainment	N.A.
Virginia	Virginia Beach	Maintenance	100
Virginia	Norfolk	Maintenance	100

<u>Project Emission Screen Analysis</u>

Air emission for the dredging and beach control operations can be predicted using estimated power requirements, fuel consumption, length of time for various operations, and the emission factors obtained from the U.S. EPA's *Compilation of Air Pollutant Emissions Factors, AP-42* and other updated documents. Emissions can be calculated for each phase of dredge vessel operation: dredging, transiting between borrow site and nearshore mooring site and return, and pumping out to the beach. Following these procedures and applying the previously calculated air emissions of a MMS operation for a beach erosion control project in Sandbridge, Virginia (which involved dredging and moving about 1.5 million cubic yards of sand over a 6-month period and would result in a release of 180 tons of NO_x emissions for a hopper dredge operation or 127 tons of NO_x for a cutter suction dredge), the proposed project emission screening analyses were conducted to decide whether the further conformity determinations based on SIP emission budgets are required.

For a typical dredging operation of 1 million cubic yard sand over an one-year period, the proposed project emission screen analysis shows the following results. The results on the following two tables serve as general indicators only. Each individual project has its own emission characteristics, and emission estimates have to be made for any particular project in order to determine whether a conformity analysis is needed.

Project Site Location (State,	**County)**	**NO_x Conformity Threshold (tons/year)**	**Estimated NO_x Emssion from Project (tons/year)**		**Further Conformity Required (Yes/No)**	
			Hopper Dredge	**Cutter-Suction**	**Hopper Dredge**	**Cutter-Suction**
New Jersey	Monmouth	25	120	85	Yes	Yes
New Jersey	Ocean	25	120	85	Yes	Yes
New Jersey	Burlington	25	120	85	Yes	Yes
New Jersey	Atlantic	N.A.	120	85	No	No
New Jersey	Cape May	N.A.	120	85	No	No
Delaware	Kent	25	120	85	Yes	Yes
Delaware	Sussex	N.A.	120	85	No	No
Maryland	Worcester	N.A.	120	85	No	No
Maryland	Wicomico	N.A.	120	85	No	No
Maryland	Somerset	N.A.	120	85	No	No
Virginia	Accomack	N.A.	120	85	No	No
Virginia	Northampton	N.A.	120	85	No	No
Virginia	Virginia Beach	100	120	85	Yes	No
Virginia	Norfolk	100	120	85	Yes	No

The screening analysis will also provide an estimation of the maximum annual volumes in cubic yards of sand to be dredged at each operation site to ensure the the project induced NO_x emissions would be below (within) the conformity thresholds in the nonattainment areas or the PSD (Prevention of Significance Deterioration) requirements in the attainment areas.

Project Site Location	**NO_x Threshold For Conformity of Sand (or PSD Limit)**	**Estimated Maximum Dredging Volumes (cu yds/year) To Meet Thresholds**	
		Hopper	**Cutter-**

(State,	**County)**	**(tons/year)**	**Dredge**	**Suction**
New Jersey	Monmouth	25	200,000	290,000
New Jersey	Ocean	25	200,000	290,000
New Jersey	Burlington	25	200,000	290,000
New Jersey	Atlantic	(100)	830,000	1,170,000
New Jersey	Cape May	(100)	830,000	1,170,000
Delaware	Kent	25	200,000	290,000
Delaware	Sussex	(100)	830,000	1,170,000
Maryland	Worcester	(100)	830,000	1,170,000
Maryland	Wicomico	(100)	830,000	1,170,000
Maryland	Somerset	(100)	830,000	1,170,000
Virginia	Accomack	(100)	830,000	1,170,000
Virginia	Northampton	(100)	830,000	1,170,000
Virginia	Virginia Beach	100	830,000	1,170,000
Virginia	Norfolk	100	830,000	1,170,000

3.3.2.3 Physical Oceanography

Physical processes on the continental shelf that have the potential to interact with sand recovery efforts include strong wave and storm-driven flows and the hydraulic coupling between positive relief features, such as linear sand ridges. The principal driving forces of water movement over the mid- to inner continental shelf are wind stress and related barotropic (*i.e.*, depth-dependent) forces, such as horizontal pressure gradients due to density differences, as well as tidal waves moving shoreward from the deep ocean. An overview of these processes with respect to major physical oceanographic features is provided in Section 2.2.5 of this report.

Over the continental shelves of the Atlantic, wind and tide-generated currents are strong in some areas and the resulting turbulence level is high. As a result of strong flows over this relatively shallow mid- to inner continental flows, quasi-steady state flows associated with strong winds and passing storms tend to become friction dominated. In other words, the principal balancing force against wind stress and associated barotropic forces that arise from water slope induced pressure gradients is bottom stress.
Calculations using turbulent flow models coupled with quadratic frictional drag formulations show that wind stress associated with a 7-m/sec wind will produce a flow that adjusts to frictional equilibrium within about three hours. The adjustment period varies directly with wind speed and inversely with water depth. Further, the limiting velocity of a longshore wind-generated flow under moderate conditions (7-m/sec wind) is about 20

cm/sec. The limiting near-bottom velocity under hurricane force conditions has been shown to be 200 cm/sec or more (Csanady 1981). Comparing this range of current speeds with critical conditions for initiation of sediment transport indicates that at least the surficial sediments of the mid- to inner continental shelf could become mobilized episodically under storm conditions (Figure 3-9).

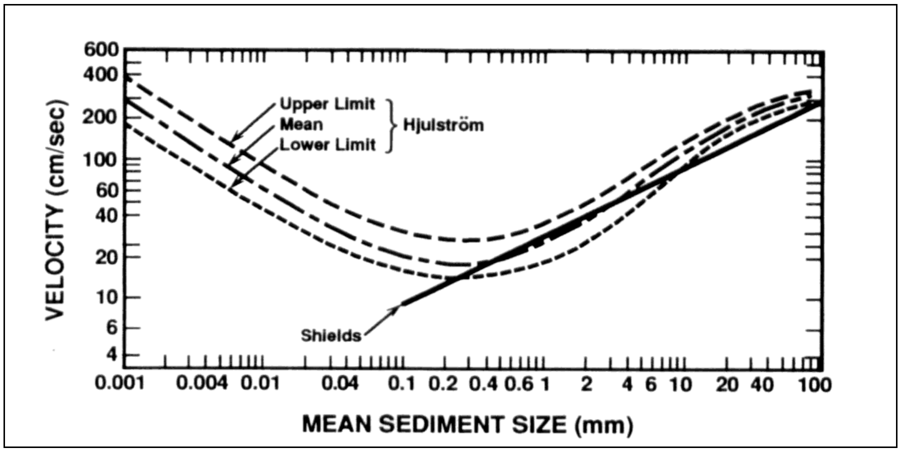


Figure 3-9. Critical conditions for sediment transport according to Shields (1932) and Hjulstrom (1935). Curves indicate that under moderate conditions (20 cm/s) sediment movement can be initiated in medium to fine sand (0.5-0.125mm).

Observational experiments carried out at depths of 15 to 30 meters within the mid-Atlantic area confirm that strong near bottom flows are associated with storms and that flows can persist in a quasi-steady state when associated with wind stress that is applied in the longshore direction (Niedoroda 1980; Lavelle 1975). In addition, near bottom and near surface cross-shore directed quasi-geostrophic adjustment currents can be associated with strong shore parallel flows. These transient and episodic current systems are apparently common in the shelf areas ranging from 10 to more than 50 meters. Thus, with respect to the potential for impacts, it is important to consider the possible hydraulic coupling between shelf hydrodynamics and linear sand ridges that may be subject to offshore dredging operations.

Topographic evaluation of linear sand ridges that may contain significant sand and gravel resources show that they are meso-scale features having dimensions of tens of kilometers in length, are up to several kilometers wide, and can have heights above ambient depths of 5 to 30 m. Observations of grain size distribution and bedform orientation associated with linear sand ridges indicate that secondary currents may be responsible for their linear topography and long-term maintenance. Finer sediment sizes occur in the crest area, whereas coarser grained sediments occur in the inter-ridge trough area (Swift *et al.* 1978; Parker *et al.* 1978). Bedforms and current lineations observed on the flanks of sand ridges have been observed at oblique orientations with respect to the longitudinal axis of the ridges.

Maintenance and evolution of linear sand ridges has been attributed to helical flows (Figure 3-10) that are topographically controlled between sets of ridges (Swift *et al.* 1973). A theoretical study by Schmidt and Dean (1989) suggested that secondary currents are related to gradients in Reynolds stress by analogy to secondary flows in channels (Einstein and Li 1958; Gerard 1978). Although the exact mechanism for evolution of linear sand ridges is not well defined, it is clear that they are dynamic and remain hydraulically active from the time of origin. McBride and Moslow (1991) summarized the origin of these features as storm reworked ebb shoals at tidal inlets and storm-reworked delta lobes at lower stands of sea level during the early to mid-Holocene Epoch. Inner shelf sand ridges that have been analyzed from historical bathymetric records have changed significantly in shape and position at the 100-year time scale. A comprehensive stratigraphic study by Rine *et al.* (1981) showed that the ridges are overturned and "re-generated" on a time scale of a few hundred years.

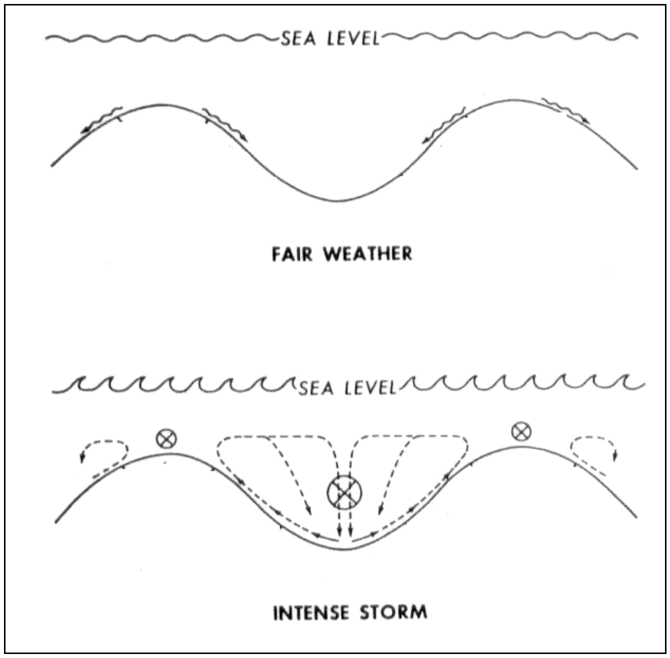


Figure 3-10. Schematic view of secondary flows over linear sand ridges during storm and fair weather conditions (from Stubblefield *et al.* 1975).

All lines of evidence indicate strong interactions between storm flows and ridge topography. Therefore if the topography of individual sand ridges is altered significantly by sand mining activities it is likely that the details of hydraulic coupling between ridge and flow will be altered to some degree. Without a quantitative model for topographic change of these relatively large-scale features, the importance of these changes on individual ridges cannot be predicted. However, possible impacts may be insignificant. If ridges are truly hydraulic in nature and if offshore dredging induces changes that are not radical, a ridge may simply re-generate topographically as it evolves over time. At the other end of the spectrum, a ridge that has been drastically reduced in sand volume may migrate more rapidly, or possibly disintegrate into a feature much more subdued in topography. For mid-shelf ridges more than 10 to 50 km from the shoreline it is difficult to conceive of any lasting impact from topographic change that may impact the nearshore zone or coastal zone. However, for sand ridges that are shoreface connected or in water depths of 20 meters or less, some influence may extend to the shoreline, especially with respect to interaction with local wave regimes. These issues are discussed in Section 3.4.2.2.

3.3.2.4 Water Quality

As discussed in Section 3.3.1 above, offshore dredging systems are either mechanical, hydraulic, or a combination of the two principles. The use of a specific system will depend on a variety of factors such as site-specific conditions, sediment characteristics, availability of systems, and economics. Dredging systems potentially used for beach nourishment along the Mid-Atlantic shelf will likely consist of hydraulic dredges such as TSH dredges and cutterhead dredges.

The primary water quality impact during the sand dredging operation will be turbidity (*i.e.*, water with elevated suspended sediment concentrations). Factors that affect the turbidity levels include the following variables (Herbich 1992):

- Characteristics of the dredged material (*e.g.*, size distribution)
- Nature of the dredging operation (*i.e.*, dredge type and size, relationship between the cutter and the magnitude of hydraulic suction, type of draghead, the magnitude of hydraulic suction and the speed of the vessel), and
- Waves and currents at the location of dredging operation.

The dispersion of turbid water during dredging throughout the area is referred to as a turbidity plume. The turbidity in the plume is generally a temporary impact governed by factors such as sediment concentration, size distribution and shape. Different dredges generate turbidity during different processes.

3.3.2.4.1 Turbidity

Trailing Suction Hopper Dredge

TSH dredges trigger a small plume at the seabed from the draghead ("benthic plume") and a larger surface plume from the discharge of overspill of water with suspended sediment from the hopper (i.e., pumping past overflow of the hopper). The overspill occurs during "economic loading" of the hopper with consolidated sediment. Economic loading entails pumping dredged material into the hopper until all the material overflows (Raymond 1984).

Surface Plume

The length and shape of the surface plume generated by the overspill depends on the hydrodynamics of the water and the sediment grain size. Plumes from coastal dredging typically are visible for only 1 to 5 km, although could extend up to 20 km (USDOI 1974). Generally, longer plumes are associated with fine-grained sediments such as silts and clays (*e.g.*, Nichols *et al.* 1990).

During offshore dredging for beach nourishment, plumes are short and measured typically in thousands of meters (MMS 1993). In a study off the French coast near LeHavre, monitoring of the suspended sediment plume from a dredging operation showed that the turbidity was elevated over an area of 50 to 70 km^2. However, particles larger than 40 microns settled within 1.5 km from the site (ICES 1977). These results suggest rapid settling of suspended matter from the borrow sites on the Mid-Atlantic shelf since most of the dredged material is sand which has a grain size of larger than 63 microns. For example, the typical grain size distribution in the upper 4 m of sediment offshore Virginia Beach was reported as 86.5% sand and 1.5% gravel, and 12% silts and clay (MMS 1996). As another example, the silt and clay content of four borrow areas offshore the New Jersey coast ranged between only 1.1 and 4.7% (Scott and Chaillou 1997).

Detailed investigations of the plume from trailing hopper dredges during construction aggregate mining were recently conducted along the coast of the United Kingdom (Hitchcock and Drucker 1996; Hitchcock *et al.* 1998). Although the volume of discharged material is much higher in mining operations for construction aggregate with on-board screening, many of the findings about the plume dynamics of suspended sediment also apply to dredging for beach nourishment. The studies demonstrated that coarse sediment fractions (>2 mm) settle out instantaneously. Most of the remaining sediment in the plume settled out within 300 to 500 m from the dredge over a period of roughly 20 to 30 minutes. This distance increased with decreasing sediment grain size. The suspended sediment concentrations returned to concentrations close to background in less than an hour after completion of dredging, depending on size and specific gravity of the material in the plume. The surface plume was visible for approximately 3 km, even though the suspended sediment concentrations in the more distal part of the plume were close to background. Hitchcock *et al.* (1998) suggested that the far field "visible" plume may consist of an organic mixture of fats, lipids, and carbohydrates disturbed and fragmented by the dredging process. Ultimately, the length of the plume depends on the hydrodynamics at the location and on the grain size of the overspilled material.

Other studies discussed in Hitchcock *et al.* (1998) also documented comparatively short plumes with suspended sediment concentrations above background supporting the conclusion that much of the discharged solids settle as a density current during the initial stages of the sedimentation process. The formation of a density current depends on the volume of overspill material and the mode of discharge such as single-pipe discharge, versus dispersion of overspill from several overboard discharge points.

Impact on Water Column: The impact of the suspended sediment plume is site-specific and depends on the specific resources at the site. Generally, suspended sediment decreases light attenuation in the water column. Light will be more scattered rather than be transmitted through the water column. Light scattering can occur at any water column level. Eventually, the suspended particles settle to the ocean floor through various settling mechanisms.

Turbidity may primarily affect the biological ecosystem. In high concentrations, suspended sediments may affect the gills of fish and impair photosynthetic processes. Finfish and other mobile organisms may temporarily migrate out of the zone of turbidity. Upon settling, the sediment can blanket or smother benthic organisms and block filter mechanisms. Other impacts of increased suspended sediment concentrations are aesthetic impacts of the surface plume and the covering of archaeological sites.

Very fine particles travel further and gradually settle out. Settling of fine particles, however, is determined by several factors such as Gaussian diffusion, as well as biological and physical processes. Gaussian diffusion principles alone would result in widespread dispersion of particles. Biological and physical processes, however, can greatly accelerate the settling velocity of particles. Biological processes include ingestion of particulate matter by organisms with subsequent excretion as denser fecal pellets. Physical processes include flocculation and aggregation of suspended matter into larger particles (also referred to as "marine snow" or "large amorphous aggregates"; *e.g.*, Asper 1987; Aldridge and Gottschalk 1988; Hay *et al.* 1990). Such processes were often not included in plume dispersion models as stated in MMS (1993): "Because most models lack representation of real mechanisms which efficiently remove fine-grained materials from the oceans, they predict continual buildup of these materials and much larger sediment plumes than are observed in field verification. This shortcoming is often realized by the developer of the model but it is usually justified as being a conservative assumption." (p.244).

The fine particles will eventually fall onto the seabed forming a thin layer. The thickness of the layer will be thicker closer to the dredge. The actual thickness is determined by the volume of material discharged and the degree of dispersion of the material. Field measurements of the thickness of the blanket are limited, although a study by Gajewski and Uscinowicz (1993) suggests that deposition is very small beyond 150 m from the dredger (Figure 3-11). Outside of the immediate area of dredging the sediment accumulation rates are on the order of millimeters per year (Oakwood Environmental 1998).

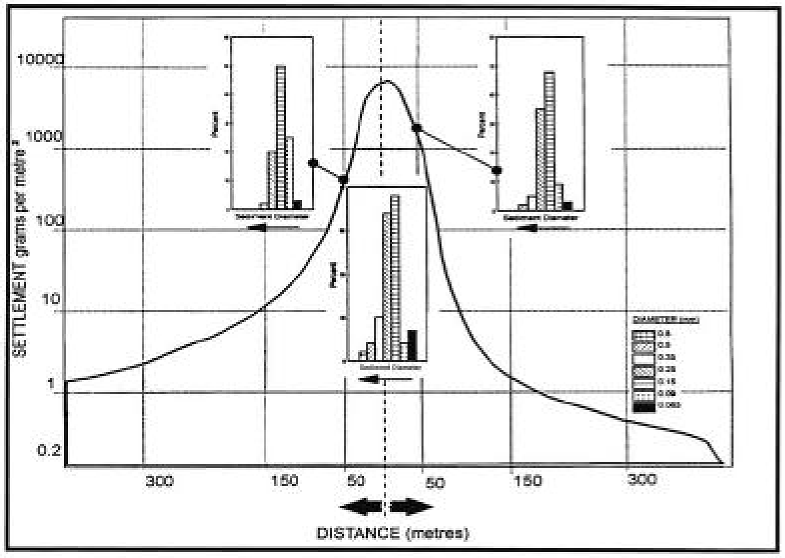


Figure 3-11. Diagram showing the settlement of overflow sediments during dredging operations fom trailer dredging in the Baltic. Particle size profiles for the sediments deposited in the track of the dredger and 50 meters on each side of the dredger are also shown. Note that the main deposition of sediment was confined to distances within 150 m on each side of the dredger track (after Gajewski and Uscinowicz 1993; adapted from Hitchcock *et al.* 1998).

The area of dispersion can be reduced through various technological means such as subsurface discharge of the overspill material, although this will result in higher accumulation rates over a smaller area. Generally, with greater dispersion, the thickness of the layer will be thinner. The most appropriate method of overspill discharge to be used for any given area will depend on the characteristics of the site such as circulation patterns, biological resources, etc.

In order to assess if turbidity causes an impact to the ecosystem, it is essential that the predicted turbidity levels are evaluated in light of conditions such as during storms. Storms on the Mid-Atlantic shelf may generate suspended matter concentrations of several hundred mg/l (*e.g.*, Styles and Glenn 1999). Concentrations in plumes decrease rapidly during dispersion. Neff (1981, 1985) reported that solids concentrations of 1000 ppm two minutes after discharge decreased to 10 ppm within one hour. Poopetch (1982) showed that the initial concentration in the hopper overflow of 3,500 mg/l decreased rapidly to 500 mg/l within 50 m. For this reason, the impact of the settling particles from the turbidity plume are expected to be minimal beyond the immediate zone of dredging (see further discusion on biological impacts in Section 3.3).

Benthic Plume

The size of the benthic plume generated by the draghead was observed by Hitchcock *et al.* (1998) as roughly 4 to 5 orders of magnitude smaller than the surface plume. During one of their surveys, the benthic plume was less than 30 m long containing suspended solids concentrations between approximately 30 and 40 mg/l. Depending on the amount of overspill material, the benthic plume may become incorporated into the rapidly descending surface plumes.

Cutterhead Dredge

Cutterhead dredges generate turbidity by the rotating action of the cutter and the swinging action of the ladder. Sediment discharges from the dredge platform itself, however, are typically limited to periods of maintenance or emergencies and are therefore comparatively short in duration and low in volume of discharged sediment. Locations of turbidity include the following:

- **Cutterhead:** The suspended sediment concentrations in the plume generated at the seabed range from 10 to 300 mg/l near the cutterhead to a few mg/l at a distance of 300 to 600 m from the dredge (Barnard 1978; Raymond 1983; Hayes *et al.* 1984; LaSalle *et al.* 1991), although most of these studies were conducted during dredging of silts and clays. The plume usually remains in the lower portion of the water column (McLellan *et al.* 1989). The size of the plume depends on a number of parameters such as equipment setup, cutterhead type, operating technique, and sediment characteristics (see McLellan *et al.* 1989 for additional details).

- **Pipeline:** If the material excavated by the dredge is pumped to the beach through a pipeline, sediment discharges could occur in locations where the pipeline breaks or where the pipeline needs to be shortened or extended through additional sections. If a pump stops functioning, for example, sediment transported in the pipeline would settle to the bottom of the line with the potential of future blockage (Huston 1976); turbidity could occur during subsequent maintenance activities. Also, connections between pipeline joints can cause turbidity if they are old or if the gaskets are worn.

- **Barges used for Transport:** If cutterhead dredges are used in conjunction with barges, rather than with a floating pipeline connected to the beach, suspended sediment plumes would form in the surface water from overflowing loads, similar to overflows on hopper dredges (see discussion above).

The primary impacts from cutterhead operations are associated with the impact to the benthic ecosystem in the immediate vicinity of the cutter. Outside of the zone of direct contact of the cutterhead and the sediment, impacts are similar to impacts from redeposited sediment from hopper dredges discussed above. However, the area potentially impacted is considerably smaller if the dredge is used with a pipeline.

3.3.2.4.2 Dissolved Oxygen

Potential impacts on the dissolved oxygen concentration in the water consist of BOD loading and generation of deep pits in the seabed:

BOD Loading in the Water Column

The bottom sediment contains organic matter in the form of refractory organic carbon and benthic organisms. Since organic material has a low specific gravity and also is associated in part with fine particles, much of the organic matter will be discharged from the hopper with the overspill. Ozretich (1981) studied the anticipated effect of organic matter in the discharge plume on the oxygen demand of the water column and of the benthic layer during marine mining operations. He concluded that entrained benthic fauna would be consumed in the water column and resettling refractory organic matter does not provide oxidizable matter to the benthic layer. In addition, the organic matter and fine particle concentrations in sand borrow areas are generally very low.

Low Dissolved Oxygen Concentration at Seabed

Dredging sand for beach nourishment does not typically create deep pits on the ocean floor. However, if deep pits or trenches are formed, low oxygen concentrations could potentially develop due to reduced flushing.

3.3.2.4.3 Contaminants

Pollutants potentially encountered in marine sediments from anthropogenic (*i.e.*, man-made) sources consist of heavy metals, organic compounds, radioactivity, garbage, and other materials. These materials are placed on the ocean floor through deliberate or random dumping of dredged material, sewage sludge, industrial waste, ammunition, garbage, etc. Areas of contaminated sediments and dredged material disposal areas are described in Section 2.2.8.7.

The presence of contaminants in dredged sediment may have an adverse impact on the water quality after discharge in the overspill. Resuspension of contaminated sediment during the dredging operation would disperse the contaminants over the seabed potentially impacting biological resources. Wide dispersion would be likely with the use of a hopper dredge since the contaminants are associated with the finer fractions of the sediment; these fractions would be dispersed with the surface plume. In addition, placing the contaminated sediment on the beach would cause adverse risks to human health by users of the beach (as well as to the health of the dredging and beach nourishment team). Due to these potential impacts, dredging for beach nourishment should not occur in areas that contain contaminated sediment. Therefore, knowledge of the chemical composition of the sediment should be obtained prior to dredging, particularly if there is a risk of contamination due to proximity to a disposal site, or if there are reports of illegal disposal in the past.

If contaminated areas were to be dredged, water quality impacts could occur. Proper site investigations prior to dredging and intermittent chemical sediment testing during dredging in case of remaining uncertainties are recommended to avoid impacts.

3.3.2.4.4 Hydrogen Sulphide

Hydrogen sulphide (H_2S) exists in anoxic sediments. Degassing of H_2S on-board the dredge would pose a health risk because it is highly toxic. Anoxic conditions form in sediments at depth depending on the organic matter content. Typically, anoxic sediment are associated with fine-grained deposits. Coarser-grained deposits such as offshore sand and gravel deposits tend to be well-aerated. Therefore, the formation of H_2S at hazardous concentrations generally would not be expected (MMS 1996).

3.3.2.4.5 Nutrients

Nutrient releases from dredged sediments are not a concern offshore due to the low organic matter concentrations in the sediment and the rapid dilution and dispersion of overspill material.

3.3.2.4.6 Petroleum Hydrocarbons and Other Waste Products

Other potential water quality impacts consist of petroleum hydrocarbon contamination from fuel spills from the vessels during fuel transfer or during accidents. However, such impacts are easily avoidable through proper management practices. The likelihood of such impacts from dredging operations is considered very low (MMS 1993). In addition, the environmental impacts from small oil spills on the water quality of the open marine environment would be expected to be minor.

Similarly, impacts could occur from discharging garbage and other waste materials. However, mining dredges have to comply with MARPOL regulations like any other vessel with stipulate adequate disposal practices of waste materials.

3.3.3 Biological Resources

Lee and Jones (1992) stated it would be rare that decreased photosynthesis from turbidity adversely impacts the overall functioning of an ecosystem in a significant way. Studies by Jones and Lee (1978) concluded that very high concentrations of suspended sediment (up to grams per liter) did not affect organisms adversely either by abrasion or by blockage. Hitchcock *et al.* (1998) suggested that the distal part of the plume may largely have only aesthetic impacts. Indeed, the impact of the distal plume on aquatic organisms may be positive through enhancement of feeding opportunities and protection from predation, although more information needs to be obtained about the nature of the matter in the distal plume.

Impact on Benthic System: Many benthic organisms are capable of burrowing through a certain amount of sediment redeposited during a storm event. Elevated suspended sediment concentrations which occur during storms typically last at least several hours. Overspill and sediment redeposition during dredging operations can be expected to have similar impacts on the benthic community as a storm event. The length of dredging in a specific area depends on the specific dredging operation and dredging pattern, and may last less than an hour. However, dredging may periodically occur in the same general area over days and weeks.

Impacts from turbidity on benthic organisms during dredging operations were reviewed in detail by Pequegnat *et al.* (1978) and Stern and Stickle (1978). Both studies concluded that impacts to the benthic populations of the marine ecosystem from turbidity are local and temporary but not permanent. Similarly, recent studies show that benthic impacts may be limited to the immediate vicinity of dredging operations (*e.g.*, Hitchcock *et al.* 1998; MMS 1996). The coarsest particles settle quickly, possibly as a density current, although most of the studies were conducted on plumes during aggregate mining operations. Depending on the form of discharge of the overspill from the hopper, density currents may not form in beach nourishment dredging operations, but coarse particles would still settle quickly with velocities following Stoke's law.

The primary ecological impact of dredging sand borrow areas will be the complete removal of the existing benthic community through entrainment into the dredge. Mortality of the benthic infauna and epifauna will occur as they pass through the dredge pump and/or as a result of being transplanted into an unsuitable habitat. In addition, excessive siltation and increased turbidity associated with offshore dredging and nourishment processes can result in impacts to marine organisms (Auld and Schubel 1978; Snyder 1976). Siltation and burial of benthic organisms and reef/hard bottom habitat is an issue of concern, and the increase in turbidity affects both filter-feeding organisms and fishes. Larval and juvenile fish, in particular, are especially sensitive to dredging-induced turbidity, as their gills may become clogged or abraded by floating particulates. Feeding ability of larval and juvenile fishes is decreased due to a reduction in available light.

3.3.3.1 Plankton, Neuston

The increased turbidity and siltation associated with dredging of sand can impact larval fish and invertebrates by clogging or abrading of gills or from direct mortality through suction in the dredge itself (Auld and Schubel 1978; Snyder 1976). Potential impacts to phytoplankton and zooplankton include the inability to photosynthesize due to decreased sunlight or decreased foraging efficiency. Van Dolah *et al.* (1992, 1994) observed, however, that the naturally high densities of phytoplankton, zooplankton, and larval organisms found in coastal waters are not significantly impacted by dredging activities. They calculated that the potential mortality caused by dredging did not equal the natural mortality rates of the populations under normal circumstances.

3.3.3.2 Benthos

Organisms living in the sediments being dredged from OCS sites will be removed and/or destroyed. The borrow areas being dredged will be recolonized by adult organisms from adjacent areas or by recruitment of larval and juvenile organisms from the surrounding area (Newell *et al.* 1998a). The rate at which a borrow area recovers and the degree to which the community returns to its original density and species composition is dependent upon the duration and timing of the dredging, sediment composition of the borrow area (Oakwood Environmental Ltd. 1998; Newell *et al.* 1998a), the hydrodynamics of the borrow pit and surrounding area (Van Dolah *et al.* 1992), the degree of sedimentation that occurs following dredging (Van Dolah *et al.* 1992), and the type of dredging equipment used to remove the sediment (Oakwood Environmental Ltd. 1998; Blake *et al.* 1996).

Abundance, biomass, diversity, and species composition are significantly decreased immediately following dredging activities (Newell *et al.* 1998a; Schaffner *et al.* 1996). Following dredging, borrow areas are quickly recolonized (1 month to 1 year) (Schaffner *et al.* 1996) by opportunistic species (e.g. the polychaetes *Streblospio* sp., *Capitella* sp., *Owenia* sp., *Scololepis* sp., and *Chaetozone* sp., and the amphipods, *Corophium* sp. and *Ampelisca* sp.) (Newell *et al.* 1998a). These opportunistic species (characterized by rapid growth and reproduction) may not be the same species that were present in the area prior to dredging and in most cases are smaller individuals living in only the top few centimeters of sediment (Newell *et al.*, 1998a). If the borrow area is not impacted by continued dredging, unusually high sedimentation rates, or some other disturbance, a natural succession of species composition should occur, potentially restoring the area to its original levels of abundance and biomass within 1-5 years (Van Dolah *et al.* 1992; Blake *et al.* 1996; Newell *et al.* 1998a) (Figure 3-12).

Newell *et al.* (1998b) measured the concentration of organic matter in the outwash from a marine aggregates dredger in the U.K. They concluded that the concentration of organic matter in the outwash from the dredger during loading operations is sufficient to account for the detectable plume beyond the point at which inorganic suspended solids have fallen to background levels. The significant quantities of lipids associated with this organic material, derived from invertebrates damaged during the hydraulic dredging process, may reduce the rate of sedimentation of material and may result in the enhanced benthic productivity beyond the boundaries of dredged areas that have been reported by others (*e.g.*, Poiner and Kennedy 1984).

If the characteristics of the site are changed by dredging such that the borrow area fills in with a different type of sediment (*e.g.* silt vs. clay) or the currents through the area are altered by the change in topography, the rate of succession could be changed, allowing different species to recolonize the area or allowing certain species to exclude other species through competition (Van Dolah *et al.* 1994; Wilber and Stern 1992; Schaffner *et al.* 1996).

Newell *et al.* (1998a) observed that borrow areas at higher latitudes recover at slower rates than borrow areas at lower latitudes. They also note that relatively weaker currents through a borrow pit could decrease the rate of recovery to as much as 2-8 years and that borrow areas with silt bottoms recover faster than pits with sand and gravel sediments. These authors also observed that there is little evidence of dredging operations affecting the biota in the areas adjacent to borrow areas. A recent investigation into the effects of aggregate mining on marine benthos found that the resuspended sediments associated with aggregate

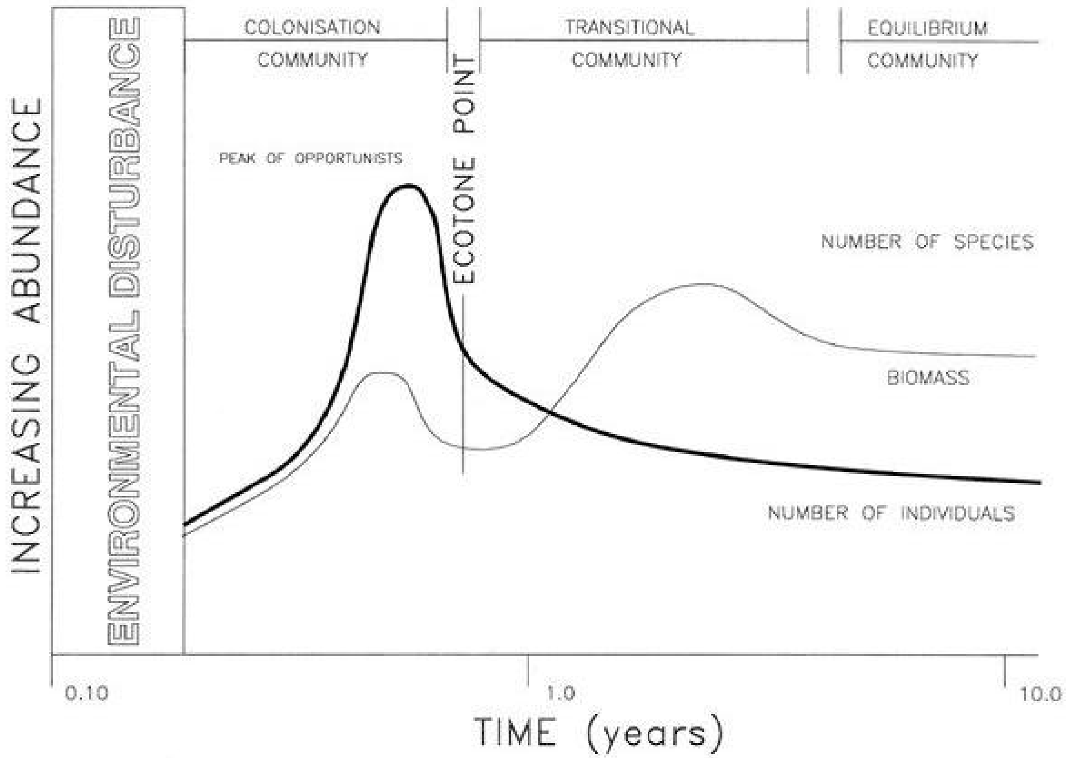


Figure 3-12. Schematic time series diagram showing a colonization succession in marine sediment following cessation of environmental disturbance. Initial colonization is by *"opportunistic"* species which reach a peak population density generally within 6 months of a new habitat becoming available for colonization after the catastrophic mortality of the previouis community. As the deposits are invaded by additional (larger) species, the population density of initial colonizers declines. This "Ecotone Point" marks the beginning of a "Transitional Community" with a high species diversity of a wide range of mixed **r-** and **K-**selected species. This period may last for 1-5 years, depending on a number of environmental factors, including latitude. Provided environmental conditions remain stable, some members of this transition community are eliminated by competition and the community as a whole then forms a final "Equilibrium Community" comprising larger, long-lived and slow-growing species with complex biological interactions with one another (based on Pearson and Rosenberg 1978, adapted from Hitchcock *et al.* 1998).

mining do not significantly impact benthic communities outside the immediate dredging area (Hitchcock *et al.* 1998).

Overall, dredging significantly impacts the benthic organisms living in the sediment of the area being dredged. Recolonization of borrow areas begins almost immediately following dredging. In the long-term, the borrow area will recover to original densities of organisms, but not necessarily to its original species composition.

3.3.3.3 Fish

Potential impacts to juvenile and adult fish include direct burial and gill clogging or abrasion. Only the less motile species of fish, or those which feed exclusively on non-motile prey, are expected to be impacted by dredging efforts (Van Dolah *et al.* 1992). Most other species will leave an area while dredging occurs, significantly decreasing their abundance and diversity for the short term, and will return to the borrow area shortly after dredging is completed. Available food sources (*i.e.*, benthic invertebrates) could be significantly depleted during dredging and may affect the foraging success of bottom feeding fish (Oakwood Environmental Ltd. 1998).

Depending on the recovery rate of the benthic communities in the dredged area, this may have short-term or long-term effects on fish distributions in a specific area. Van Dolah *et al.* (1994) observed that even though species diversity and abundance were significantly lowered by dredging efforts, the borrow area had completely recovered to its original species densities and composition within six months.

3.3.3.4 Non-Endangered Marine Mammals

The potential impacts of offshore dredging activities are generally similar for all of the species of marine mammals described in Chapter 2. Potential direct impacts include disturbance to benthic and aquatic habitats and disruption of the prey base, interference with filter feeding, noise disruption, and potential collisions between equipment or transport vessels and marine animals. Certain types of impacts, such as vessel collisions, are more likely to affect certain species which have surface feeding or resting habits, such as right and humpback whales. Noise associated with dredging operations may have a greater affect on species that are sensitive to low-frequency sound than on species with different optimum hearing ranges. Rather than analyze the different hearing ranges of all marine mammals in the study area, it should be assumed that noise will cause avoidance responses to some degree in all species.

Overall, the continental shelf off the Delmarva peninsula in the Chesapeake Bay region harbors the greatest concentration of marine mammals and sea turtles in the mid-Atlantic, particularly during the spring and summer months. As described in Chapter 2, the mid-shelf east of the Chesapeake Bay region is a high use habitat for marine mammals, with piscivorous species generally concentrated off the coasts of Delaware and Maryland during these seasons (Kenney and Winn 1986). This area is primarily used as foraging and developmental habitat by these animals, rather than for breeding. In these areas, disruptions to the prey base are likely to have more significant impacts than in other, less frequently utilized habitats. Food items of marine mammals include benthic fauna, plankton, fish, and squid.

Dredging for sand can affect the ability of marine mammals to obtain food in several ways. The most evident impact is a substantial initial reduction in the benthic invertebrate fauna in the dredged area (USACE 1998d). Dredging operations can cause the animals to avoid particular feeding areas due to noise or vibrations. Decreased feeding success and prey availability may occur in areas of increased activity-related turbidity. Turbidity plumes caused by offshore dredging can affect species of concern and their prey in a variety of ways. Decreased visibility can affect foraging ability by those species that use sight as a primary means to locate prey. Plankton growth may be affected by the decrease in light levels caused by the presence of a fine sediment plume. However, studies that have attempted to assess the extent of plankton resource entrainment during the hydraulic dredging of sand borrow areas have not identified significant impacts (Van Dolah *et al.* 1992, 1994). Particulate matter may have deleterious effects on filter feeders and gilled organisms, although many mobile, free-swimming organisms such as pelagic fish can avoid turbid areas (NRC 1985).

These effects can also be expected outside the immediate vicinity of the dredging activity. Operations using hopper dredges tend to be discontinuous and associated plumes would be dispersed over a larger area. However, because the concentration of the suspended particles in the plume diminishes rapidly with time and distance from the source, the effects on fauna further away from the activity are reduced. In general, the effects of turbidity on phytoplankton (due to light reduction) or on pelagic fish and invertebrates (due to gill irritation and reduction of light levels for visual feeders) are considered small (MMS 1993). Within the water column, the effects of particulates on the drifting biotic communities are considered negligible because of the limited area affected and the typically short exposure time (NRC 1985). A suction hopper dredge is usually on-site for three to four hours during a 24 hour period, with the remaining time spent in travelling and unloading sand (Drinnan and Bliss 1986). This discontinuous method of offshore dredging allows suspended sediments to dilute, dissipate, and settle.

Many of the potential effects upon marine mammal prey species as described above would be considered indirect impacts. Direct impacts from offshore dredging can also occur. The most severe would be death or injury caused by collisions with activity-related equipment or support vessels. Some marine mammals that sleep or rest motionless at the surface, or that are slow swimmers, may have difficulty avoiding fast-moving vessels.

Noise is byproduct of any offshore operation that can also directly affect marine mammals by altering normal behavior patterns. Some researchers have suggested that most marine mammals become habituated to low-level background noise, such as ship traffic and offshore petroleum activities, however some animals show abrupt responses to sudden disturbances (MMS 1993). Stationary dredging operations in the arctic did not greatly disturb beluga and bowhead whales, but their swimming patterns did change within 2.4 km of dredging operations (MMS 1983). It may be difficult to eliminate all noise effects if activities are proposed in sensitive habitats.

3.3.3.5 Sea Turtles

The potential impacts to sea turtles by offshore dredging activities are similar to those described for marine mammals above. Potential impacts include disturbance to benthic foraging habitats and disruption of the prey base, interference with underwater resting habitats, noise disruption, and potential collisions between equipment or transport vessels and marine turtles. The period of greatest sea turtle activity in the project area is spring and summer, during which time numerous, mostly juvenile sea turtles, particularly loggerheads, Kemp's ridleys and leatherbacks, forage in the back bays and shallow waters of the Chesapeake and Delaware Bays and off the coast of New Jersey. Sea turtles feed on benthic invertebrates, fish, crabs, jellyfish, sponges, and sea grasses. Dredging in shallow areas can destroy foraging habitat for sea turtles. Farther offshore, drifting beds of *Sargassum* seaweed are used by hatchling turtles as nursery habitat. These beds occur in areas where different tides converge and sink. Disturbance of such beds of seaweed removes potential juvenile turtle habitat and may harm hatchlings inhabiting them.

Direct impacts to sea turtles are also similar to those described for marine mammals. Controlled experiments with loggerhead turtles showed avoidance responses to low-frequency sounds (O'Hara 1990). Collisions with vessels are a particular concern for marine turtles because they mate, bask, and forage on the surface. Between 1986-1993, about nine percent of stranded sea turtles (living and dead) off the coast of Florida had propeller or other boat strike injuries. Vessel strikes were determined to be an important cause of sea turtle mortality (Lutcavage *et al.* 1996). In the Chesapeake Bay, boat propeller wounds accounted for seven percent of deaths of sea turtles stranded between 1979-1988, or five to seven turtles per year. It is estimated that approximately 400 sea turtles per year are killed by boat collisions off coastal beaches (NRC 1990). Another serious impact to sea turtles is entrainment in hopper dredges. The use of hopper dredges can kill turtles caught in dragheads. In Florida, there were 149 confirmed incidents of sea turtles entrained by hopper dredges working in two shipping channels from 1980-1990. Nearly all turtles entrained by hopper dredges were dead or dying when found (NRC 1990).

3.3.3.6 Threatened and Endangered Species

Threatened and endangered species in the study area include all sea turtles described in Chapter 2; the blue, fin, humpback, right, and sperm whales; the shortnose sturgeon and the sand tiger shark, which is a candidate species. Potential impacts to all marine mammals and sea turtles have been described in the sections above.
Similar impacts related to turbidity plumes including loss of benthic food supply through siltation and displacement of organisms, gill abrasion from suspended sediments, and loss of habitat through alteration of bottom features may effect shortnose sturgeon and sand tiger shark. Habitat alterations from discharges, dredging or disposal of material into rivers, and related development activities involving estuarine/riverine mudflats and marshes are known threats to shortnose sturgeon (NMFS/USFWS 1998). Shortnose sturgeon spawn in late April in the lower Hudson, but are found from the Gulf of Maine to northeast Florida. Because shortnose sturgeon do not breed in offshore marine areas, impacts to this species caused by offshore dredging activities are expected

to be relatively minor or insignificant. Natural shoal areas, like Hen and Chicken Shoal, have been documented as possible nursery sites for sand tiger sharks. Sand tiger sharks are currently being identified as candidates for possible addition to the List of Endangered and Threatened Species. This area could be designated closed in the near future (J. Tinsman, Delaware Artificial Reef Program, pers. comm., Feb. 1999). Even though sand tiger sharks are somewhat sluggish, it is expected that they could readily avoid the other areas affected by sand mining activities.

3.3.4 Socioeconomic Environment Impacts

3.3.4.1 Commercial and Recreational Fisheries

Mid-Atlantic fisheries target a diverse array of coastal and estuarine species both commercially and recreationally. The harvest of these renewable, marine resources is essential in developing and maintaining the socioeconomic status of the coastal regions and neighboring vicinities of the Mid-Atlantic Bight. It is important to realize the necessity of maintaining a healthy, marketable stock to continue economic stability. Identification, management, monitoring, and protection of essential spawning and nursery habitat for commercially and recreationally viable marine species is critical to the preservation and continued survivability of a harvestable stock (ASMFC 1998). Negative impacts on eggs, larvae, and juvenile marine species can inevitably effect future harvests and projected stock abundance.

The impacts that various marine activities have upon the aquatic environment vary with increased operational intensity and duration. The degree of impact on a fishery is in direct correlation with the effects on the biodiversity, biomass, population density, and the extent of dredging based on method, intensity, and dredge duration at one particular site. Dredging projects have the potential to induce injurious impacts on key fishery resources and possibly the fishing industry itself (Wainwright *et al.* 1992). These effects have been an issue of environmental significance for decades, yet little research has been accomplished when dealing with direct population-level impacts on demersal fishes or benthic macroinvertebrates (Wainwright *et al.*1992).

Overall, the potential impacts of dredging to commercial and recreational fisheries will result from a complex combination of physical, biological, and human effects (Oakwood Environmental 1998). The level of social impact upon the commercial and/or recreational fishing industry from dredging could also be an important indicator of socioeconomic disruption (Oakwood Environmental 1998).

Commercial Fisheries

The following section describes the potential impacts to four subdivisions of commercial fisheries. These categories include demersal, pelagic/anadromous, pelagic, and catadromous. The shellfish and demersal fisheries have been combined into one category since both are harvested from the benthic regions of commercial fishing areas.

Demersal

The fisheries most vulnerable to potential disruptions of commercial harvest from dredging activities are the shellfish and demersal fisheries. For a more concise and centralized reference, both the shellfish and demersal fisheries will be categorized together in this section. The most serious impact of offshore dredging is the loss of major commercial species of benthic shellfish (Naqvi and Pullen 1982). The most commercially viable species potentially effected by the utilization of coarse-grained borrow areas is the surfclam. Other species of concern are the summer flounder, winter flounder, ocean quahog, Atlantic scallop, horseshoe crab, and the channeled and knobbed whelks. Those species described in previous chapters that are not mentioned are either transient to the study area or are minimally effected by dredge operations due to motility. Potential impacts that could possibly upset the demersal and groundfish fisheries economically are biologically connected to potential harvest abundance.

Even though biological effects may impact a benthic community locally, the economic effects could be more regionally widespread. This is due to the localization and utilization of preferred commercial grounds by local fisherman. Landings of surfclams from the EEZ continue to be somewhat stable due to the large standing stock relative to annual quotas. A majority of fishing concentration for the surfclam occurs off the coast of Atlantic City, New Jersey.

Possible biological outcomes that could effect sustainable commercial yields are degradation of benthos, destruction of habitat, alteration of endofaunal habitat, direct removal or burial of demersal species from entrainment and sediment resettlement, depletion of valuable fish habitat, and loss of primary food sources that support and sustain healthy fisheries (Newell *et al*. 1998a). The alteration and settlement of different sediment types to dredged areas could also allow the recolonization of commercially unimportant species to exclude commercially viable species through competition, thus impacting harvest (Van Dolah *et al.* 1992; Newell *et al.* 1998a). Major alterations to the physical topography can also impede commercial fishing activities such as trawling which, in turn, can lead to potential loss of gear.

Recently, there has been concern with the decreased integrity of the lobster habitat caised by sediment migration from beach nourishment projects in Monmouth County, New Jersey. Testimony from local lobster trap fishermen at recent public hearings indicated a sharp decline in harvested catch from historic nearshore fishing grounds such as the Shrewsbury Rocks (T. McCloy, New Jersey Division of Fish, Game and Wildlife, pers. comm., May, 1999). The decline in catch may be associated with a change in sediment type created by the extensive offshore dredging operations in those areas adjacent to primary commercial trap fishing grounds. These primary commercial fishing grounds are shown in Figure 3-13 provided by the New Jersey Division of Fish, Game and Wildlife.

Pelagic/Anadromous

The pelagic/anadromous fisheries include those marine species that are free-swimming or highly migratory and therefore can avoid the areas of dredge activity. Direct impacts to this fishery could result from noise, entrainment, gill clogging, depletion of benthic food sources, and loss of relict shoal areas that may be utilized as navigation points for some migratory marine species (T. Goodger, NMFS, pers. comm., April, 1999). The importance of benthic communities in marine food webs leading to exploitable yields of pelagic and anadromous fish is widely recognized. Decimation of benthic community populations could result in a depletion of food source for the pelagic species (*e.g.*, red drum, weakfish, silver hake) that rely on these organisms for sustenance (Newell *et al.* 1998a). Yet, the mobility of these fish species enables them to avoid the dredging operational areas and obtain food sources in other unaffected forage areas incurring insignificant adverse impacts to the fishery (T. Goodger, NMFS, pers. comm., April, 1999). There is also evidence that dredging operations may benefit fish species that feed within the water column by suspending

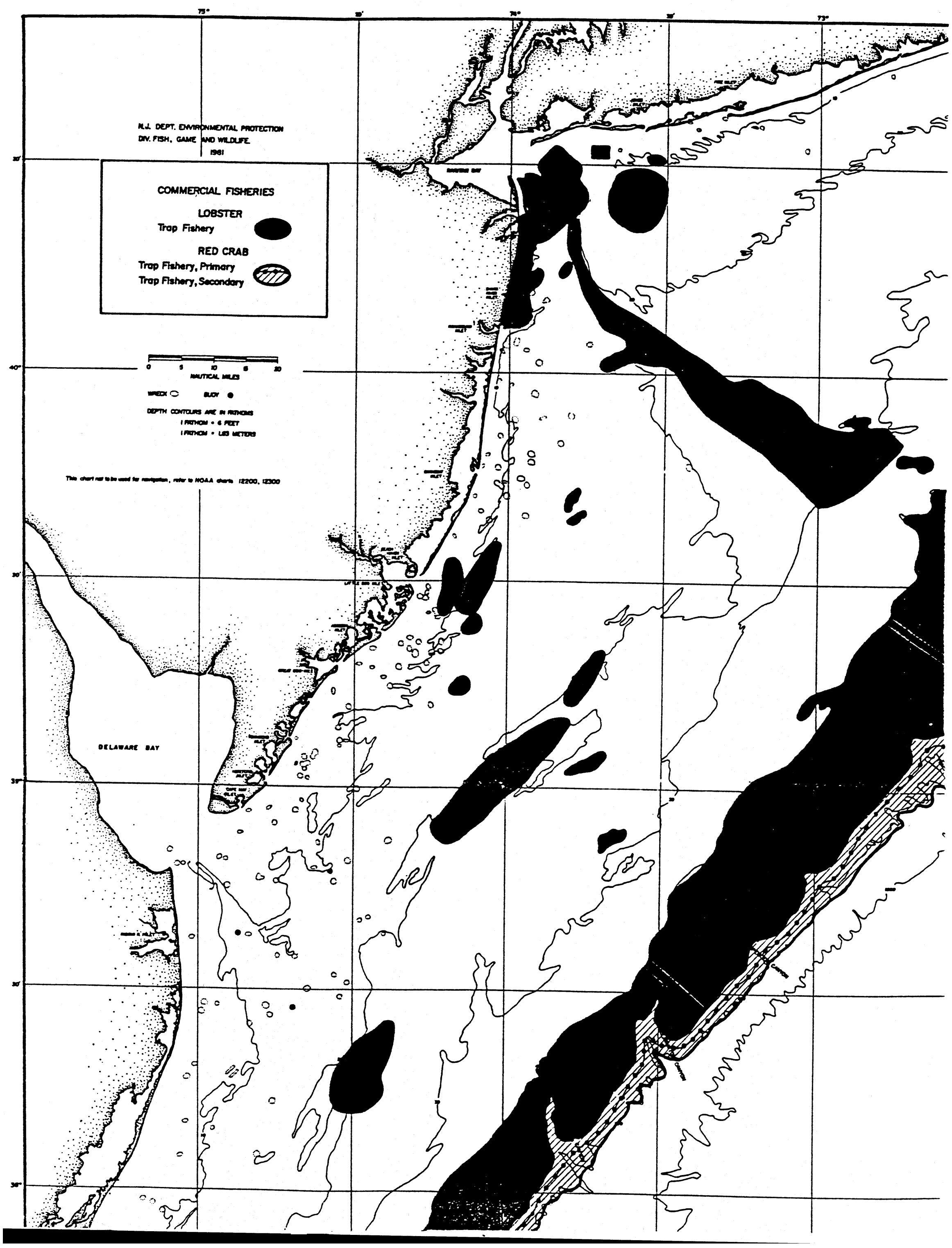


Figure 3-13. Primary commercial fishing grounds off the New Jersey coast.

food material (Courtenay *et al.* 1972). Bordering regions of dredge activity could provide suitable fishing grounds due to the resuspension of food particles. Spawning, egg dispersal, and juvenile development for these species occurs inshore and away from the study area resulting in minimal impacts to the stresses already imposed upon future stock abundance.

Pelagic

The mobility of pelagic fishes enables them to be less vulnerable to adverse effects of beach nourishment and offshore dredging operations (Naqvi and Pullen 1982). Short-term beneficial impacts could result from an increase in suspended, nutritive materials as a food source creating areas of feeding concentrations. The adverse impacts to potential harvestable yield should be negligible.

Catadromous

Impacts to the catadromous fishery are unascertained due to the lack of scientific data, but best available information points toward similar impacts encountered by other migratory species during offshore dredging operations (J. McClain, NJDEP, pers. comm., April 1999). Possible adverse effects could stem from juvenile and adult entrainment, noise, migratory disruptions, trophic disturbances, and loss of primary food sources. Beneficial impacts could result in increased survivability for juveniles associated with temporary protection of localized turbidity. Since the juveniles remain within the nekton during migration and the adults are highly motile, negative impacts to population size should be minimal. The fishery, in turn, should be unaffected.

Recreational Fishery

In the Mid-Atlantic Bight, the five most common recreationally caught fish are summer flounder, Atlantic croaker, black sea bass, weakfish and striped bass. These species accounted for approximately 63 percent of the total recreational catch by number in 1996 (Rountree *et al.* 1998). Of these, the only fish that might be potentially impacted due to habitat degradation is the summer flounder. The other species are either highly motile, pelagic, can easily avoid areas of dredging operations, or inhabit hard substrate regions that are representative of structure that is not easily reached by dredge equipment. The majority of recreational anglers that utilize private boats or charters tend to fish in areas that are not within areas being considered as borrow areas. Since no known areas of concentrated, recreational angling occur in the potential sand borrow areas, and since the targeted, adult species sought should not be effected by dredging operations, the fishery should be unaffected. Basically, if the targeted species are either avoiding the area due to noise, turbidity, or local disruptions caused by sand mining or not prone to inhabit the area, the recreational fishery will avoid the area as well and relocate to the areas containing the greatest fish concentration. Recreational fishing for shellfish is very limited offshore and therefore should be unaffected by dredging at borrow sites.

3.3.4.2 Artificial Reefs

Artificial reefs have increased the opportunity for recreational angling by providing structural habitat for marine organisms, as well as numerous target destinations for fisherman. A major issue relative to the justification of reef sites is their potential as a producer of future fish stocks or as a concentrator of adult fish populations used to increase catches per unit effort recreationally (W. Figley, NJDEP, pers. comm., April 1999). Data from a comparison study of New Jersey reef sites young of year (YOY) productivity versus that of the bay and non-ocean reef sites productivity provides data that juvenile fish inhabit these areas (Figley and Dixon 1994). During this four month study, a total of 9 species of fish and 35 species of invertebrates were collected from all study sites combined, with YOY fish diversity being greatest in the experimental habitats on the ocean reef sites. Of the 9 species of fish collected, 4 YOY fish species and juvenile lobster were found to inhabit the reef sites, exceeding the juvenile fish biomass of the ocean non-reef sites and the bay sites by 3% and 14% respectively. Gut analysis of adult ocean pouts and black sea bass (predominantly hard-substrate inhabitants) revealed that 72% of the ocean pouts and 12% of the black sea bass contained YOY fish in their stomachs. This study indicates that juvenile fish, as well as juvenile lobster, do inhabit artificial reef sites.

The acknowledged existence of juvenile species on artificial reef sites supports a better assessment of dredging impacts to the reef sites and their inhabitants. The loss of juveniles could possibly impact future commercially and recreationally viable fish stocks.

Since artificial reef programs are managed through non-profit state agencies, the size, location, type of structure, current and potential productivity, duration of site, and biodiversity of these sites are better evaluated by state and should be assessed individually. Approximately half of the sites should not be directly affected by nearby dredging since they are outside the study area (NOAA nautical charts). Indirect conflicts that may arise are with some juvenile fish, sessile invertebrates, and epifaunal inhabitants. Impacts on the marine biota could include gill clogging and possible sediment burial of encrusting or sessile organisms from the settlement of particulate matter dispersed in turbidity plumes if dredging operations are in close proximity to reef sites. This is dependent on wave action, current, and operational intensity and duration.

Ordinarily, reef sites should be avoided by operations employing bottom gear. Included are trawl fisheries, net and dredge fisheries, cable or pipeline projects, and sand or mineral mining endeavors. Reef structures can impede, entangle, and destroy bottom gear and endanger the operators. Dredging and commercial fishing gear can alter the reef habitat and remove structure. Structure that is moved outside of reef site areas becomes unknown and uncharted, and poses potential hazards to surrounding sea floor operations (NJ Ocean Reef pamphlet). Designation of no dredging from April 15 through August 30 in near shore habitats of Delaware Bay may be implemented in the near future. The closure would include any type of beach restoration projects that would inhibit horseshoe crab migration or smother spawning grounds (J. Tinsman, pers. comm., Feb. 1999).

3.3.4.3 Archaeological and Cultural Resources

Activities which may affect offshore historic and archaeological sites include dredging and anchoring. Potential submerged cultural resources in coastal areas include shipwrecks as well as fortifications, early historic coastal settlements, and prehistoric sites that have become inundated through coastal subsidence, migration of shorelines and beaches, and the rise in global sea levels since the end of the last ice age.

Chapter 2 described how it is unlikely that the targeted sand deposits that would be mined for beach replenishment contain undisturbed prehistoric site remains, as inundated archaeological sites are most likely to be found in silt and clay deposits that represent former freshwater floodplains, bays, lagoons, and lakes. Sand and gravel deposits, on the other hand, would have a low potential for containing preserved sites. In addition, coarse-grained sediments like sand and gravel represent high energy deposition that would have eroded rather than preserved remains of Native American occupation.

As a Federal agency, the MMS ensures that its undertakings do not adversely affect potentially significant historic properties. To achieve this goal, the NOAA and the MMS maintain separate databases on historic shipwrecks. These databases should be consulted prior to approval of any dredging operation and if a proposed action will potentially impact a historic shipwreck, a remote sensing survey may be performed to determine a more precise location of the remains so that they can be avoided. Geophysical data such as shallow seismic profiles and sediment cores collected within offshore borrow areas should also be reviewed to ensure that there is no potential for prehistoric sites within the areas that will be impacted by dredging operations. This is MMS' standard policy on all sand and gravel projects.

MMS's involvement in the protection and management of archaeological and cultural resources on the OCS is mandated by environmental regulations detailed in Chapter 5. These statutes include: (1) NEPA [P.L. 91-190] which declares as a national policy the preservation of important archaeological resources on the OCS; OCSLA [P.L. 95-372] which mandates that activities must not disturb any significant archaeological resources located on the OCS; and (3) NHPA [P.L. 89-665], as amended, which states that any Federal agency, prior to approving Federally-funded undertakings, must take into consideration the effects of that undertaking on any properties listed on or eligible for the National Register of Historic Places.

3.3.4.4 Infrastructure

Major submarine cables and pipelines are charted. Not all cables and pipelines are required to be buried, but may either rest upon the substrate or may be partially exposed due to shifting sediment. Since there is a recommended one nautical mile buffer zone bordering both sides of existing TAT cables, offshore dredging operations should avoid these regions and should have a minimal impact to existing cables. If uncharted cables are encountered, gear could be compromised and cables could be damaged resulting in costly reparations. Familiarity of the bathymetry and infrastructure in areas of possible offshore dredging operations is necessary to reduce the risk of gear damage and crew jeopardy.

3.3.4.5 Shipping/ Navigation

Offshore dredging can be accomplished in areas of high volume vessel traffic. The proper day signals or navigation lights for the dredging vessel should be visible during the appropriate times of day and must comply with 72 COLREGS requirements. The 1972 International Rules of the Road (72 COLREGS) govern the color, placement, range of visibility, and use of lights and shapes on all seagoing vessels and apply to all vessels operating on U.S. waters outside inland demarcation lines.

Designated areas of high traffic are Chesapeake Bay, Delaware Bay, and New York Harbor. Commercial and private vessels of varied tonnage frequently transit these areas and their movements should be taken into consideration to maximize crew and vessel safety. Types of vessels that may be encountered include tugs in-tow, barges, passenger vessels, tankers, commercial fishing vessels, sailboats, dredgers, and an array of private, recreational vessels. Since offshore dredging operations will be conducted outside of state waters in areas of low vessel congestion, the disruption of normal traffic flow from the correlating traffic schemes should remain unhindered. However, the vessels being utilized for offshore dredging operations will contribute to the overall traffic volume when travelling to and from site locations which could possibly increase chances of navigational mishap.

3.3.4.6 Military Areas

As described in Chapter 2, there are historic and ongoing military activities within the study area which have potential consequences for dredging and nourishment operations. Material placed during a recent beach nourishment project in Bethany Beach, Delaware contained ordnance (K. Ramsey, Delaware Geological Survey, pers. comm., April 1999). In April of 1999, the USACE began a Time Critical Removal Action at Bethany Beach, Delaware to remove unexploded ordnance and to determine if closure of the beach was necessary. The preliminary scan lasted approximately one month and three weeks and revealed a total of 11 shells, 10 of these discovered between Broadway and Lexington Avenues in Bethany Beach (R. Williams, USACE, Baltimore District, pers. comm., September 1999). The 7-inch shells were classified as 40mm mark II high explosives and 40mm mark II armor piercing. All discovered ordnance was removed from the beach and closure of the beach was not necessary. One shell was discovered in Middlesex Beach and removed from the surf zone. Known areas of potential hazard are documented on NOAA nautical charts yet, unknown areas do exist. In areas of suspected danger, caution should be administered. Literature relating to periodicity and duration of military activity for various localities of the study area should be reviewed on a regular basis. Information pertaining to military activity and to those regions of prospective closure or limited access are updated in the monthly publication of *Notice to Mariners* and generalized in the appropriate Coast Pilots.

Failure to remain informed to the most recent updates of military areas and newly discovered danger areas could jeopardize crew safety and compromise gear.

3.3.4.7 Dredged Material Disposal Sites

The material being dredged requires no usage of dredged material disposal sites since the sand is either going to be transported by hopper or pumped directly to the designated area of restoration by pipeline. Five of the seven EPA sanctioned disposal sites are not in the vicinity of the pre-identified borrow areas. Borrow areas in Virginia have not been identified to date. The five EPA sanctioned disposal sites located in New Jersey are all inshore. In contrast, the borrow sites for that region are outside the 3-mile limit. There should be no impact to the inhabitants of these five disposal sites.

Benthic communities have established themselves at disposal sites. Lobsters and other bottom dwellers are known to inhabit areas composed of substrate placed at dredged material disposal sites. These areas should not be effected since they lack the aggregate sediment being sought. Indirect impacts to organisms inhabiting disposal sites are minimal. Areas of historic significance may contain well-established benthic communities. If dredging is performed near these designated areas, the biological communities could be indirectly impacted by the settlement of particulate matter on the substrate from turbidity plumes.

3.4Beaches/Onshore Habitats

Beach restoration by the emplacement of sand from borrow sources has been on going in the United States since 1922 when a project at Coney Island was constructed. The 1984 Edition of the “Shore Protection Manual,” USACE, Washington, DC, lists thirty-nine federally funded beach nourishment projects completed in the US from 1955 to 1979 for a total fill volume of over 77 million cubic yards. Current estimates for beach renourishment projects completed or projected for the Mid-Atlantic states are presented in Table 2-26. These estimates include over 64 million cubic yards of initial fill and over 4.5 million cubic yards of annual replenishment.

The initial design template used for the 1922 construction work was less than optimal and subsequent projects varied in design until beach nourishment guidelines were published by the USACE which suggested using the “overfill factor” proposed by James (1975). This information was included in Technical Report 4 “Shore Protection, Planning and Design” and subsequently replaced by the “Shore Protection Manual” (USACE 1984). The curves provided in the 1984 manual have been the basis for the design of beach fills for nearly twenty years. In 1994, the Corps of Engineers established new alternatives to the overfill factors contained in the 1984 manual. The new design criteria addresses important aspects such as storm effects, dependency of beach profile on sediment size distribution, length of project, coastal structures and long shore transport. The new alternative methods included a consideration of cross-shore transport, along shore
spreading of fill material and the response of the fill to wave conditions at the site. These guidelines are contained in EM-1110-2-3301, Design of Beach Fills, USACE, Washington, DC, 1995.

Design of Beach Nourishment Projects

A large number of factors are considered in the design of a beach nourishment project. These include an economic analysis and justification for the project as well as a detailed study of the beach area and its environs. Selection of design parameters should be based on up-to-date data on wind-wave climate storm characteristics, shoreline change history, sediment characteristics, sediment budget and littoral draft characteristics, borrow material availability and suitability and environmental considerations. The parameters are used to evaluate project conditions and alternatives. The design work includes determinations of berm elevations, width, dune elevation and volume, project boundaries and termination of fill renourishment cycles and fill material properties.

3.4.1 Emplacement Techniques

Once a design has been completed, a borrow area has been identified and all environmental factors have been addressed, the project is ready for construction. Two basic types of dredging techniques used are cutterhead dredges with pipelines and suction hopper dredges (with or without pump-out capability). Since all beach nourishment projects are subjected to competitive bid the final choice of methodology and equipment is often dependant on Contractor's choice.

Construction Template

The construction template defines the shape of the fill profile at the time of fill placement. The fill volume will be the difference between the construction template and the actual beach profile (cross-section) obtained shortly before commencement of construction. Profiles or templates are usually defined at 100-foot intervals along a project beach. The profiles extend from slightly landward of the dune crest along the entire beach to a point offshore where the seabed profile depth is considered stable. The construction profile of the offshore slope is usually between 1:20 and 1:30 from the low water datum to its intersection with the existing bottom (closure point). Construction profiles are normally out of shape with the natural shape as the prevailing coastal processes are expected to reshape the profile starting immediately after placement. The volume of fill material must allow for this natural readjustment toward a more natural slope (winnowing process). During placement, the fill is continually monitored to determine actual foreshore slopes. This monitoring is usually conducted by the contractor surveyors.

Design Template

The design profile is the shape the fill material is expected to achieve after being worked by natural coastal processes over the first few months or a year after the fill operations are completed. The design profile may be based on the pre-fill profile if the fill material (borrow sand) matches the native beach sand. In such cases, the beach profile after nourishment is the same as the profile before nourishment except for a transition of the beach seaward (Figure 3-14).

Construction Methods

The following scenarios are descriptions of the various methods used to deliver or emplace the sand on the project beach. Each of these scenarios have common elements which include dredging of fill from a designated borrow source offshore, transporting the sand ashore by either a pipeline or barge or hopper dredge or combination of all three, spreading of sand by pipeline movement and construction machinery and constant monitoring of fill volume to complete the construction template.

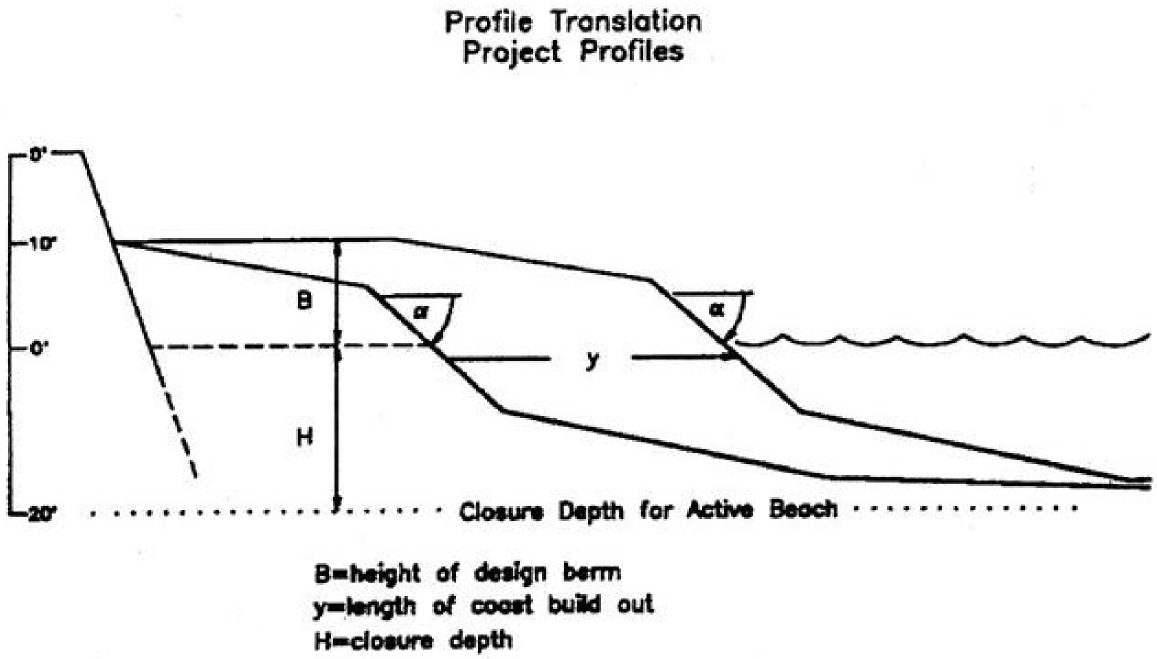


Figure 3-14. Native beach profile versus minimum design beach profile using fill similar to native fill. Design profile is same shape translated seaward.

Case 1: Cutterhead Dredge with Pipeline

This is the most common method used in the U.S. The cutterhead dredge is anchored in a borrow area offshore within a few miles of the project beach. Fill sand is pumped directly from the dredge to a position on shore via a floating or submerged pipeline. The end of the pipeline is moved by heavy equipment to distribute the fill. Additional lengths of pipe are added to extend the pipeline along as the filling process proceeds. Bulldozers are used to distribute and grade the fill to conform to the construction template. The lengths and the production rates of the pipelines may be increased by the use of booster pumps. Booster pumps are usually contained on barges that are anchored offshore.

Case 2: Cutterhead Dredge and Barges

A beach restoration project at Rockaway Beach, New York is described by Murden *et al.*, 1985. This project involved the placement 4,095,000 cubic yards from a borrow area 8.0 miles from the beach site. The construction plan involved a cutterhead dredge pumping sand into scow barges at the borrow site which in turn were towed the eight miles to Rockaway Inlet and into Jamaica Bay to a rehandling station. The sand fill was liquefied into a slurry mixture by high pressure jets, removed by suction pumps and pumped 2,000 ft. or more for placement on the beach. The pumps at the rehandling site were 6,000 horsepower. The pumps were able to move the sand a total pipeline distance of about 18,000 ft without the assistance of booster pumps.

Case 3: Suction Hopper Dredge

The same authors describe a similar beach restoration project using the same borrow area. The contractor in this project elected to use a suction hopper dredge. The dredge plant used was the hopper barge “Ezra Sensibar” which has a maximum capacity of 16,000 cubic yards. Since the barge is not self-propelled, a tug boat fitting into the notched stern of the barge provided the mobility power. After loading, the hopper dredge barge proceeded to a transfer station that consisted of, a work barge holding the seaward end of a 4,000 foot submerged pipeline. The dredgers pump-out line was then connected to the end of the pipeline on the work barge. Following liquification of the dredged material in the hopper bins by high pressure water jets, the sand slurry was pumped through the pipeline to the beach. The pump-out capacity of the hopper dredge was sufficient to move the material without further booster pumps. During a normal 24 hour workday, three loads totaling approximately 33,000 cubic yards were dredged and transferred to the beach.

Case 4: "Rainbow" Method

Land reclamation and beach nourishment projects have been carried out in Europe and other countries using the "rainbow" method. This method employs a trailer suction dredge discharging its cargo of fill material directly on to the beach by use of high pressure pumps. Similar projects have been undertaken by this method in Poole, England and Denmark.

The choice of this method of course depends upon the local site conditions. These factors include the bottom profile that will allow the vessel to make a safe close approach to the shore and favorable, current, wind, waves and swell conditions. It is highly unlikely that there are many locations on the US east coast that would permit consideration of this method of sand placement.

Potential Environmental Impacts of Emplacement

The environmental impacts of sand emplacement for beach restoration may include the following:

- Changes in the nearshore bathymetry occasioned by movement of finer fill material winnowed from the newly-placed sand directly offshore and deposited nearby. Following placement of material in the nearshore the formation or growth of offshore bars is expected. This, however, is usually of temporary character and over several months of wave and tidal action which causes a redistribution of material from the placement area, the substrate elevations and slopes will normally return to pre-placement conditions.

- Longshore Transport – Following placement, there will be an increase in longshore transport of sediment away from the filled beach. This movement may have a beneficial impact on those beaches without jetties or groins downdrift of the restored beach, but will only be of a temporary nature.

- Dredged material pumped into the site will undergo dewatering and compaction and a portion of the material (depending on size content) will run off as a turbid effluent. The water surrounding the beach in process of restoration will become slightly turbid but this condition should not be very long lasting.

- Aesthetic Appearance – Changes in the appearance of a beach may occur depending upon the characteristics of size, type and color of the borrow sand as compared to the native sand. While grain size distribution is the primary consideration in evaluating the suitability of borrow material other factors such as shell content, sediment type and color may have some importance particularly where recreational use of the beach is important.

- Burial Impacts – The placement of new sand onto an existing beach may have lasting biological and cultural impacts.

These impacts are discussed in more detail in the following sections.

3.4.2 Physical Environment

3.4.2.1 Air Quality

Air emissions during the placement of sand on the beach would result from bulldozers and other equipment on the beach used in the construction of the berm. These activities woiuld obviously occur within the state boundary. A detailed discussion of air quality issues is provided in Section 3.3.2.2.

3.4.2.2 Wave Climate

There have been very few studies of possible physical impacts of offshore sand mining on nearshore habitats and adjacent beaches. At issue is when alteration of bottom topography resulting from dredging significant volumes of sand from the inner continental shelf will have any measurable influence on the nearshore wave regime and local littoral sediment budget. Another possible impact from offshore dredging could result from the extraction of large volumes of sediment from ebb or flood shoals at tidal inlets. In the present analysis, only dredging activities beyond the three-mile state/federal boundary are considered. Thus, the major activity considered here is the impact of the dredging of shoals at or beyond the three-mile limit on nearshore wave climate and beach stability.

In a quantitative study by Maa and Hobbs (1998) conducted at the Virginia Institute of Marine Science (VIMS), the possible impacts on local conditions of dredging Sandbridge Shoal for beach quality sand were considered. Specifically considered were breaking wave heights, breaking wave angles, and associated longshore sediment transport rates. The proposed sand recovery project at Sandbridge Shoal consisted of extracting 1.6 million cubic yards of sand from a rectangular borrow area approximately 1.5km x 0.5 km in dimensions. The borrow area, which was located at the three-mile limit was in a depth of approximately 10 m (approximately 33 feet) at the crest of the shoal. To quantify the possible impacts of dredging at the borrow site the observed wave field derived from NOAA buoy observations was coupled with a numerical refraction-diffraction wave model. Analysis of the wave climate data showed that a very low percentage (about 5%) of observed waves exceeded 2 meters in significant height and 12 seconds in period. Based on the assumption that shorter periods and smaller waves would not interact with the crest of the shoal at 10 meters depth, the wave refraction-diffraction model was exercised to examine the possible impact of more severe waves. Model runs included pre-dredging topography of the shoal crest and model topography assumed the upper 2 meters of sand was removed from the 500 m by 1500 m borrow area. Results of the model runs indicated that only slight changes in wave angle at breaking would occur for the most severe wave conditions as a result of the modified shoal topography. For waves of 6.2 m in height and 20 sec in period arriving from the NE quadrant, the maximum predicted change in breaker angle was 7%, according to model results. In other model tests involving less significant wave heights and shorter periods the predicted change in breaker angle was approximately 2%. Maa and Hobbs pointed out that the predicted changes were on the order of the accuracy and prediction of the observed wave direction (+/-5%)

The VIMS study also examined the possible impacts of topographic modifications of Sandbridge Shoal on longshore transport rates. It was reasoned that modification of breaker angle, even if slight, could effect a measurable change in longshore transport rates. The breaker angles and breaker heights predicted by the numerical wave model for pre- and post-dredge topography of the shoal was used to estimate longshore sand transport using an empirical formula given by Gourlay (1992). The Gourlay formula was developed by modifying the longshore transport formula of Komar and Inman (1970) to include the influence of non-uniform breaker height along the coast. Changes in predicted longshore transport rates were considered to be minor even under the severest observed wave condition of Hsig=6.2m and peak period of 20 seconds. Locally, the predicted rate of longshore sand transport varied along the coast in the study area and was less than a few percent in most cases. Waves approaching from the NE quadrant were predicted to have the most impact with respect to pre- and post-dredging topography of Sandbridge Shoal, reaching a maximum of a 20% shift in the predicted transport rate.

In a more recent study of the Sandbridge Shoal borrow site, also conducted at VIMS, conclusions similar to those of the Maa and Hobbs study were reached by the investigator (Boon 1998). The wave refraction/diffraction model applied in this study (Boon 1998) included somewhat different capabilities compared to the "ray tracing model" used in the earlier work (Maa 1995). The model was based on a parabolic wave equation that is applicable over mild slopes and allows specification of a two-dimensional wave spectrum as forcing at the model boundaries. Thus the spectral Ref/DIF-S model is capable of calculating significant wave heights within the model domain, as the sum is discrete wave component. This differs from the model applied in the earlier study (RCPWAVE) which calculates wave height in terms of monochromatic conditions. REF/DIF-S can also be considered weakly nonlinear since it employs Solitary Wave theory in shallow water where small amplitude wave theory (Stokes theory) no longer applies (Kirby and Ozkan 1992). In the 1998 study, hindcast wave climate was investigated using the WES-CHL Wave Information System or WIS. Based on a 20-year hindcast from 1975 through 1995 it was determined that the most severe waves, occurring with a frequency of 1 to 2% were characterized by waves 12 to 16 seconds in period, 5 to 7 m in height and approached from easterly to north easterly quadrant. Applying these conditions as spectral input to the REF/DIF-S wave model, it was predicted that small but measurable changes would occur as a result of dredging a 1 to 3 m deep cut of sand from the surface of Sandbridge Shoal. Specifically, results of the analysis indicated that slight changes in the significant wave height would occur as a result of topographic changes in Sandbridge Shoal. The post-dredging model runs indicated a quieting of the water inshore of the dredged area. Another conclusion of this model study was that longshore variations in significant wave height resulting from topographic change of the shoal could result in two dimensional circulation patterns in the surf zone, or rip currents (Boon 1998).

The review of the very limited existing quantitative work of dredging nearshore shoals for sand resources indicates that the physical impacts are expected to be very small and insignificant for the most part. Quantitative work conducted at VIMS indicates that any impacts are likely to be related to severe and extreme wave conditions that can interact with nearshore and shoreface connected linear shoals. Linear shoals are common on the inner continental shelf of the mid-Atlantic region. Thus, in view of the previous work conducted at VIMS, it is useful to 1) review existing wave climate data from the region for the occurrence of severe and extreme wave conditions, and 2) to assess the possible interaction of these conditions with inner shelf topography in areas that are potential sources for offshore dredging. The following sections provide analysis of wave clime and wave-topography interaction.

3.4.2.2.1 Wave Information System (WIS) for Mid-Atlantic

In order to examine wave data for severe and extreme conditions a long time series of data is required that includes the effects of storms. The only data source meeting this requirement is the WIS developed at WES CHL. The WIS data consists of hindcasts of significant wave height and peak wave period predicted at hourly intervals. CHL maintains two primary data sets, each consisting of a 20-year hindcast. For the Mid-Atlantic analysis the 1976 to 1995 hindcast data are used because it includes the effects of tropical storms, whereas the earlier hindcast data (1954-1975) does not include hurricane or tropical storm data. The wave hindcast is based in a discrete spectral model (Resio 1989) which predicts wave height, frequency and wave energy propagation from historical records of wind velocity and/or atmospheric pressure gradients. For storm conditions, a kinematic analysis is performed on the storm track and pressure/wind fields to assure that extreme conditions are accounted for properly.

The WIS hindcast stations are shown in Figure 3-15. WIS stations relevant to this analysis include Station 78 off the south shore of Long Island through Station 53 just north of Cape Hatteras. Table 3-3 lists the coordinates and depths for these stations, along with the percentage of extreme waves hindcast for these locations.

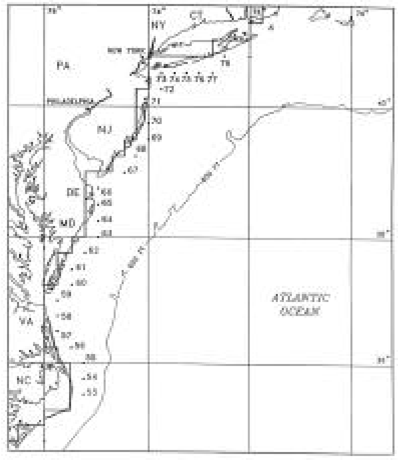


Figure 3-15. Location of WIS Stations 63 through 78 in the Mid-Atlantic region.

Regional differences in wave climates were reviewed under Section 2.2.5.4 of this report. Analysis of data collected at NOAA buoys indicates that waves observed well out on the continental shelf where water depths exceed 15 to 20 meters are higher (more energetic) in the southern reaches of the mid-Atlantic region. On the average, significant wave heights observed off the Long Island coast at similar depths were lower or less energetic. Conversely, observed wave data collected under the NEMO network very close to the shoreline in water depths of 10 meters or less, indicate more energetic conditions along the Long Island and New Jersey Coast compared to the nearshore wave climate along the Delmarva Peninsula and the Outer Banks of North Carolina. The difference in the nearshore wave climate is most likely explained by the greater nearshore depths of the Long Island and New Jersey inner continental shelf compared to the innershelf further to the south. In the nearshore region approaching depths of 10 m, attenuation of wave energy is less in the northern portion of the mid-Atlantic region and thus the nearshore wave climate is more energetic. Conversely, the wave climate further offshore, in water depths greater than 15 or 20 m, is less energetic off the Long Island coast due to the orientation of the Long Island shelf, which provides some protection from wave fetch of the extreme north Atlantic Ocean.

Table 3-3 also includes a listing of the percent occurrence of waves greater than 2 m in significant height and longer than 12 sec in period. Since the WIS Hindcast Stations are positioned in relatively deep water (Table 3-3), the hindcast results agree qualitatively with NOAA Buoy observations. Hindcast severe and extreme wave conditions at Stations 78 through 71 distributed along the south shore of Long Island and in the apex of the New York Bight have a frequency of less than 2% (Figure 3-16). Severe wave conditions were hindcasted at a frequency of between 2 and 3% at Stations 71 through 59 (Figure 3-17). In the region between the entrance of Chesapeake Bay and Cape Hatteras, hindcast data indicate the occurrence of severe and extreme wave conditions between 3 and 4% of the time. Within these areas, however, the hindcast at Stations 53 and 58 indicate severe conditions occurred more than 4% of the time (Figure 3-18).

3.4.2.2.2 Possible Zones of Impact

From the analysis of hindcast and observed wave data, it seems likely that there are several locations within the mid-Atlantic region where topographic changes from offshore dredging could combine with severe and extreme wave conditions to cause measurable changes in the local wave and sand transport regime. To assess this possibility a simple numerical model of wave refraction was developed according to linear wave theory and driven according to the expected severe and extreme wave conditions extracted from the WIS

Table 3-3. Severe and extreme wave frequency at WIS hindcast stations in the mid-Atlantic

region

WIS Station	Latitude	Longitude	Depth (m)	% Extreme Waves
53	35.50N	75.25W	27	4.4
54	35.75N	75.25W	29	3.9
55	36.00N	75.25W	37	3.4
56	36.25N	75.50W	27	2.7
57	36.50N	75.75W	18	2.5
58	36.75N	75.75W	11	4.8
59	37.00N	75.75W	14	2.9
60	37.25N	75.50W	24	2.9
61	37.50N	75.50W	18	2.5
62	37.75N	75.25W	18	2.9
63	38.00N	75.00W	18	2.8
64	38.25N	75.00W	16	2.6
65	38.50N	75.00W	18	1.2
66	38.75N	75.00W	18	2.2
67	39.00N	74.50W	18	2.2
68	39.25N	74.25W	18	2.4
69	39.50N	74.00W	22	2.7
0	39.75N	74.00W	18	2.6
71	40.00N	74.00W	18	2.3
72	40.25N	73.75W	27	1.4
73	40.50N	73.75W	18	1.5
74	40.50N	73.50W	18	1.6
75	40.50N	73.25W	24	1.6
76	40.50N	73.00W	31	1.5
77	40.50N	72.75W	37	1.4
78	40.75N	72.50W	27	1.4

data set. The parameters defining the wave conditions include waves between 10 and 20 seconds in period and between 2 and 6 meters in height. This covers the range of conditions applied in the studies by Maa and Wang (1995) and by Boon (1998), as well as the range of conditions summarized for each WIS Station in Table 3-3.

The numerical model used to assess the interaction of severe waves and nearshore topography is based on linear wave theory outlined by Dean and Dalrymple (1991). In addition to predicting wave amplitude according to linear theory the model also included a ray-tracing algorithm to describe wave direction according to location and depth over irregular topography (Noda 1974). An energy conservation equation was used to calculate energy flux with wave propagation and a wave breaking criteria was included according to Weggel (1972). The model was designed to assess the potential for wave-topography interaction, rather than to provide quantitative predictions for a particular set of wave and topographic conditions. Under this condition, the model was applied over generic test case topography developed from a library of beach and nearshore profile data maintained at the Florida Institute of Technology. The test case

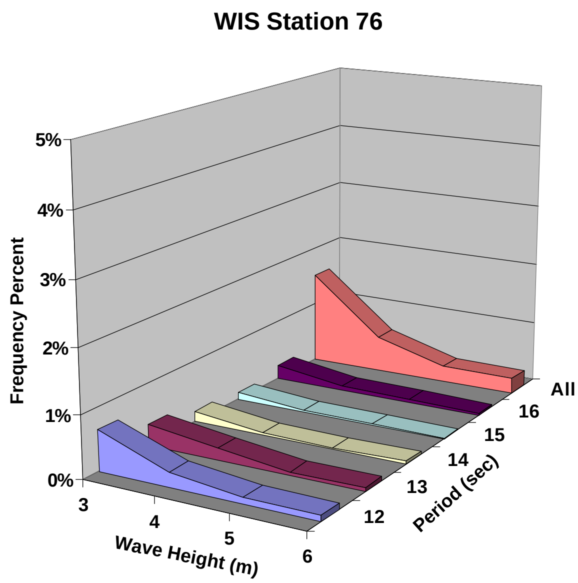


Figure 3-16. Frequency of extreme waves at WIS Station 76 (see Figure 3-15 for location).

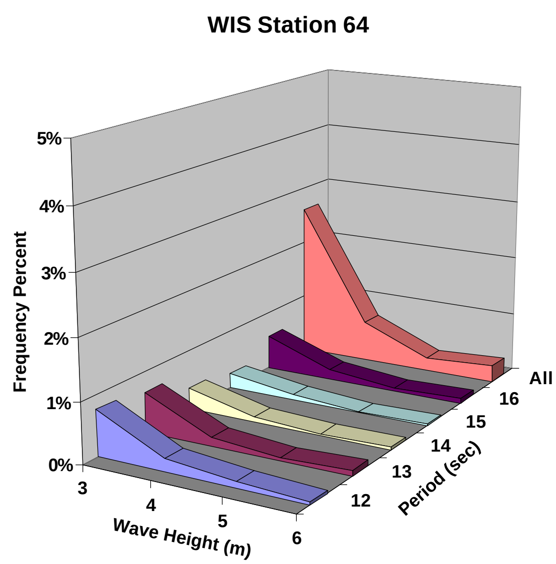


Figure 3-17. Frequency of extreme waves at WIS Station 64 (see Figure 3-15 for location).

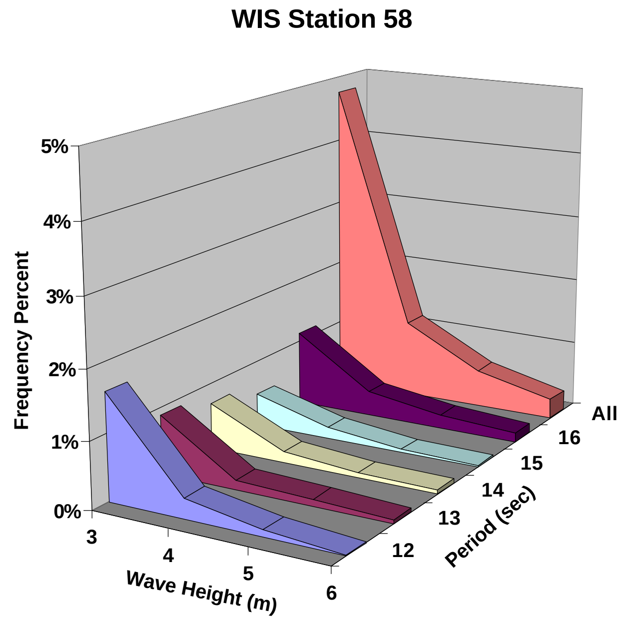


Figure 3-18. Frequency of extreme waves at WIS Station 58 (see Figure 3-15 for location).

(Figure 3-19) has the typical concave upper shoreface profile similar to the equilibrium profile that can be specified from the distance Power Law described by Dean (1977, 1983). The test case included two mounds of "sand" centered at 5.3 km offshore (Figure 3-19). This topography was used to create a topographic variation to test the various applied wave conditions with respect to refraction, wave energy flux and possible wave breaking. The offshore distance was selected to provide topographic features that cross the three nautical mile (approximately 5.5 km) limit. The crest of the mounds were specified at a depth of approximately -10m and the sides of the features sloped down to the ambient depth.

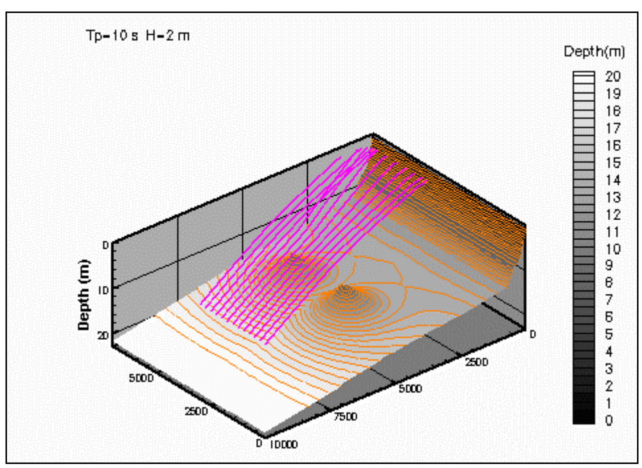


Figure 3-19. Predicted refraction of a 2m, 10 sec wave moving over a 10-meter deep shoal situated at the 3-mile limit. Cross-shore and alongshore distances are in meters.

Conditions set in the model includes waves ranging from 2 to 6 m in height and from 10 to 20 seconds in period. Results of the model tested showed that waves 10 seconds and longer were refracted over the topographical features situated at the 3-mile limit (Figure 3-19). The 6-m high model wave was predicted to break over the crest of the model shoal features at all periods specified in the model runs (Figure 3-20). The minimum condition specified in the model test cases was a 2-m wave having a period of 10 seconds. Under these conditions, the model results also indicated refraction over the crest of the shoal. Predictions of energy flux indicated a drop in the rate of wave energy flux as the wave passed over the shoal followed by an increase in energy flow as the waves moved between the shoals and the shoreline (Figure 3-21). Similar to the refraction patterns, the slowing of wave energy flux is an indicator that the waves are interacting with the shoals.

Results of the model test show that severe to extreme waves can be refracted over shoals as far as 3 nautical miles offshore if the depth at the crest can reach a minimum depth of about 9 to 10m (about 30 to 33 feet). Waves at the lower end of the range described as severe (2-m height, 10 sec in period) can refract at the crest of such shoals. Larger waves, in excess of four meters in height may also break over the crest of nearshore and shoreface-connected shoals.

In order to use this information to define the location of possible impacts along the mid-Atlantic region, the depth and topography at, and in the vicinity of, the three-mile Federal/state boundary was reviewed for relevant features. These data were collected from the standard NOAA nautical charts and special bathymetric charts used to describe nearshore topography.

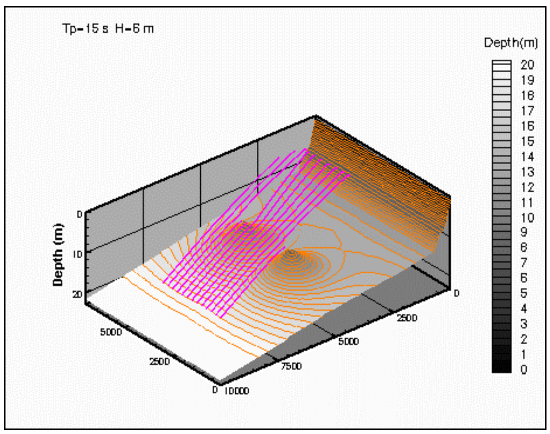


Figure 3-20. Predicted refraction and breaking of a 6 m, 15 sec wave moving over a 10-meter deep shoal situated at the 3-mile limit. Cross-shore and alongshore distances are in meters.

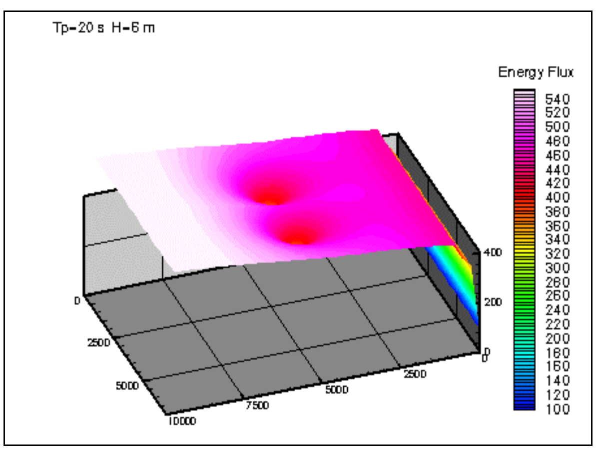


Figure 3-21. Predicted decrease in energy flux as waves propagate over shoals located at the 3-mile limit and having a crest depth of approximately 10m.

Figure 3-22 summarizes the depth at the 3-mile limit in the mid-Atlantic area. A total of 427 nautical miles were inspected beginning at the international limit offshore of Shinnecock Inlet and ending at a point just north of

Cape Hatteras. Along this line a total of 11 zones have depths of 10 m (approximately 33 feet) or less. All of these areas occur south of Long Island, and are most frequent along the Delmarva Peninsula. A few of the areas are less than one nautical mile in length. The larger areas are usually defined by one or more linear shoals that trend obliquely with respect to the adjacent shoreline and cross the three-mile limit. Table 3-4 describes the major features of each area, including the name, if any of the associated shoal feature.

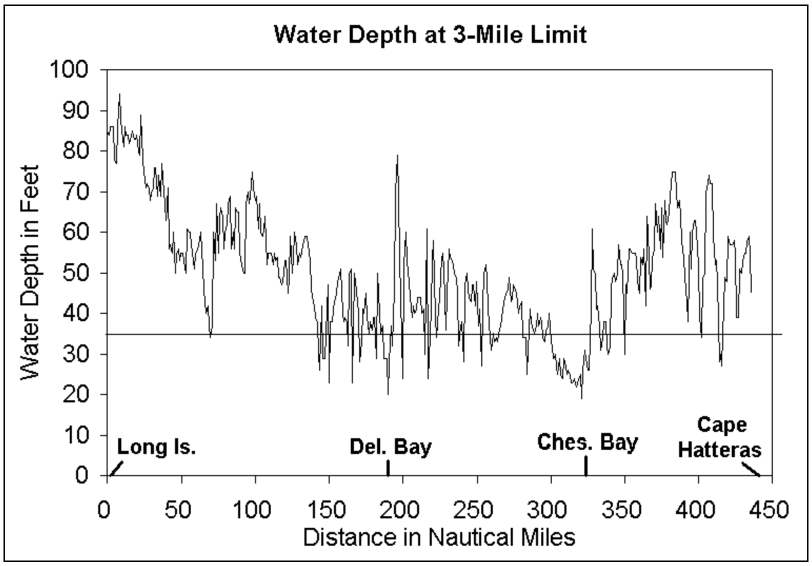


Figure 3-22. Water depths at the 3-mile state/federal boundary in the mid-Atlantic region of the U.S.

Table 3-4. Sand source zones of possible impact from severe and extreme waves.

Zone	Location (Nautical Miles)	Description	Minimum Depth (ft)
1	143 -151	Brigantine to just south of Atlantic City	26
2	181-192	Entrance of Delaware Bay	20
3	199-230	Various shoals from Cape Henlopen to just north of Ocean City, MD, Fenwick Shoal and Great Gull Bank	24
4	240-241	Small shoal off mid-Assateague Island	28
5	251-264	Blackfish Bank to Chincoteague Shoals	15
6	275-285	Paramore Banks	25
7	295-325	Ebb shoal of Machipongo Inlet at S. end of Hogg Is. to inbound Ches. Bay nav. Channel just north of Cape Henry	19
8	333-340	Sandbridge Shoal just south of VA Beach	26
9	349-351	Shallow zone off Back Bay and Currituck Sound	30
10	402-403	Crest of Platt Shoal	34
11	415-418	Wimble Shoal off Hatteras Is.	27

Figure 3-23 shows the location of the 12 zones described in Table 3-3. The "red" zones depicted on the map of Figure 3-23 indicate "caution areas" where a more detailed analysis of the possible impacts of offshore dredging should be completed prior to excavation. Such analysis could include the application of more sophisticated numerical models of wave refraction-diffraction and simulations of wave-induced sand transport as a function of pre- and post-dredging topography. A combination of local wave climates and the magnitude of the planned excavation will determine the significance of possible impacts. The 1 to 3 meter excavations of Sandbridge Shoal studied by Maa and Hobbs (1998) and by Boon (1998) were predicted to have very limited, if any impact on the nearshore sediment budget and wave regime. However, much larger excavations involving removal of major portions of a sand shoals may lead to more significant impacts. Ongoing MMS studies for New Jersey, Maryland, and Delaware do include a numerical modeling component using more sophisticated models such as REF-DIFS. A recently-awarded cumulative modeling study (to Applied Coastal Research and Engineering in May 1999) will use either REF-DIFS or STWAVE to examine cumulative effects of multiple extractions offshore all of the east coast states from New Jersey to central Florida.

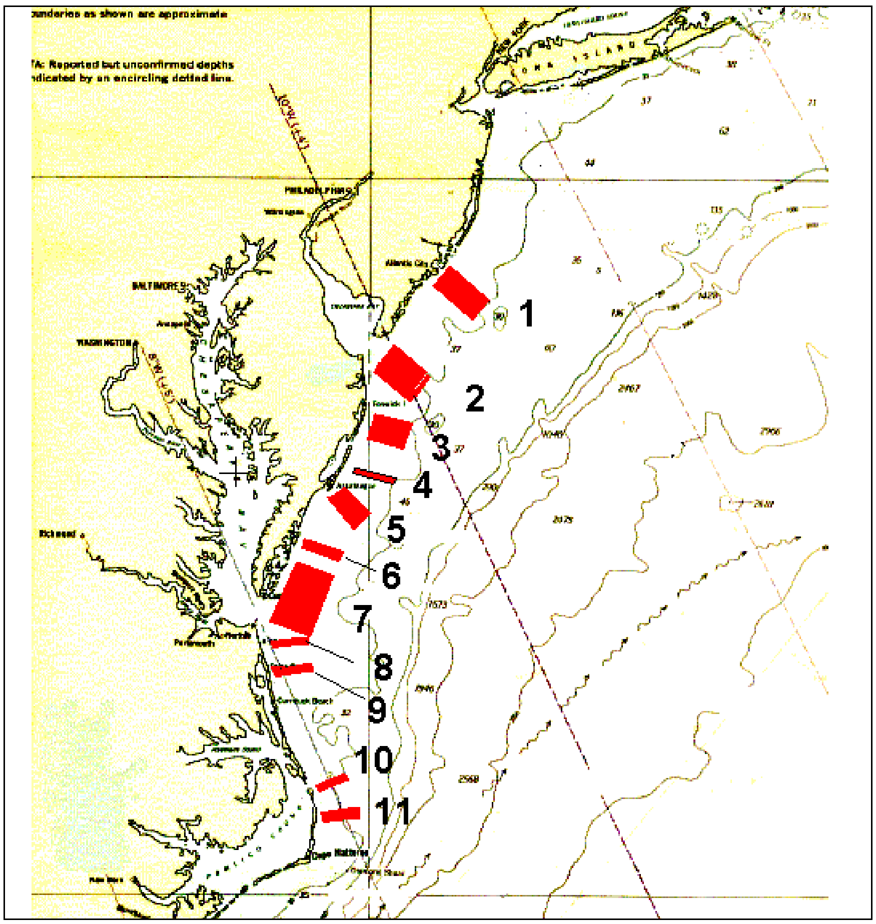


Figure 3-23. Location of zones where severe and extreme waves may interact with shoals and impact the adjacent shoreline (see Table 3-4 for further description).

3.4.2.3 Sediment Characteristics

Ideally, the borrow material obtained for a beach nourishment project should have the same mean grain size and size distribution (sorting factor) as the native material on the beach to be nourished. If the borrow material has a smaller mean grain size and significantly different size distribution, the profile will be out of equilibrium with the local wave and current environment, and will therefore be quickly eroded either offshore or alongshore. Coarser sediment placed on the beach will better withstand erosion; however, if it is too coarse it will not be as aesthetically pleasing as finer grained sand and is usually not preferred for recreational beaches. The suitability of potential borrow areas is evaluated using methodologies contained in the USACE's Shore Protection Manual (1984 and revisions).

3.4.2.4 Water Quality

Beaches are harsh environments due to their exposure to waves, tidal activity and storm activity. Sediments in the surf zone of beaches exposed to the open ocean are constantly reworked. The turbidity levels in the water vary greatly depending on the weather conditions.

Effects on water quality from sand emplacement from offshore sources are typically minor and short-term. Turbidity levels increase in the vicinity of the discharge point but do not have an adverse impact on the ecosystem in the surf zone. During monitoring of a beach nourishment project in South Carolina, Van Dolah *et al.* (1992, 1994) observed that these turbidity levels were elevated in the immediate vicinity of the pipeline outfall, but that turbidity levels were not considered unusual relative to normal fluctuations and natural conditions in the surf zone during storms. Schubel *et al.* (1978) reported that 97 to 99 percent of the sediment in the slurry settles out within a few tens of meters after being discharged from the pipeline. Turbidity generated in the vicinity of the outfall disappears in a few hours after termination of discharge (Van Dolah *et al.* 1992). The biological ecosystem in this zone is adapted to such conditions. Therefore, impacts from turbidity generated during the beach nourishment process should be temporary.

For a few months after completion of beach nourishment, the fine-grained sediments may be winnowed from the beach (USACE 1996b). Winnowing could result in turbidity levels above background concentrations on calm days. However, impacts from winnowing are mainly aesthetic. However, high erosion rates of beach fill could cause adverse impacts such as shoaling of nearby navigational channels (Ashley *et al.* 1987). Anoxic sediments and nutrients may be released during beach nourishment. Any remaining sulfides are rapidly oxidized and fine materials that contain higher concentrations of organic matter are generally moved offshore (Naqvi and Pullen 1982).

3.4.3 Biological Resources

A variety of marine organisms are potentially impacted by placement of fill material on intertidal or subtidal portions of the beachface. In general, these organisms are able to persist in the dynamic beach environment because they have adapted to conditions such as high wind and wave energy and periodic burial.

3.4.3.1 Benthos

As with benthic organisms living in borrow areas, benthic organisms are significantly impacted by beach nourishment activities (Nelson 1985; Van Dolah *et al.* 1992). These impacts, however, are considerably shorter in duration than the impacts observed in offshore borrow areas. Because benthic organisms living in beach habitats are adapted to living in high energy environments, they are able to quickly recover to original levels following beach nourishment events; sometimes in as little as three months (Van Dolah *et al.* 1994; Levison and Van Dolah 1996). This is again attributed to the fact that intertidal organisms are living in high energy habitats where disturbances are more common.

Because of a lower diversity of species compared to other intertidal and shallow subtidal habitats (Hackney *et al.* 1996), the vast majority of beach habitats are recolonized by the same species that existed before nourishment (Van Dolah *et al.* 1992; Nelson 1985; Levison and Van Dolah 1996; Hackney *et al.* 1996). Rakocinski *et al.* (1996) monitored a beach nourishment project in which the subtidal habitat below the nourishment area silted in with fine grain particles following nourishment. The changes in substrate type changed the composition of the benthic organisms in the subtidal zone, altering the ecology of the beach.

Hackney *et al.* (1996) designated indicator species, for the South Atlantic Bight, that could be used to monitor the recovery of benthic organisms impacted by beach nourishment projects. The species include *Emerita talpoida* and *Donax* sp. (swash zone), *Ocypode quadrata* (supralittoral zone), and the amphipods *Orchestoidea* and *Talorchestia* (high beach zone). They also set criteria that an indicator species must meet in order to be an effective measure of nourishment impact. The indicator species: 1) must be easily sampled for cost effectiveness, 2) should have life histories similar to other benthic organisms, 3) should be persistent members of the beach community, 4) should have sufficient wide-spread distribution to allow comparison between areas, and 5) should be species that represent important food items to predators.

At least three mechanisms of recruitment back onto a beach exist for benthic organisms. They include: recruitment of juveniles and adults from adjacent areas, deposition on the beach by dredge pipeline during sand placement, and the vertical migration of organisms through the sediment after it has been placed on the beach (Van Dolah *et al.* 1994). These mechanisms depend on the characteristics of the sediment being placed on the beach. Sediment that is of different grain size than the underlying beach or has been compacted by placement equipment could decrease the rate at which a beach is recolonized (Van Dolah *et al.* 1994; Nelson 1985).

3.4.3.2 Fish

Little direct information is available describing the impacts of beach nourishment to fish species found in beach habitats. The majority of fish living in surf zone habitats are very motile and can easily escape the potential threats of nourishment activities (Van Dolah *et al.* 1992; Hackney *et al.* 1996). The greatest impacts of nourishment activities to fish communities are the initial decrease in abundance during nourishment, the potential for gill clogging caused by increased turbidities, the temporary removal of benthic food sources, and the possibility of direct burial of demersal fish (Nelson 1985). These potential impacts are short-term and are not associated with the higher mortality rates of dredging borrow areas.

3.4.3.3 Birds

Bird species that use beaches and onshore habitats for breeding and nesting are more likely to experience significant impacts from beach nourishment activities than those species that only use an area to feed or rest while migrating through the region. Beach-nesters are particularly vulnerable to predators and human disturbance. These types of birds have suffered a significant loss of beach habitat to human development and activity (*e.g.*, USACE 1998a), and as such, many are listed as threatened or endangered. These are discussed in the next section. Alterations to nesting or feeding habitats caused by the physical placement of sand in particular locations could result in negative impacts if critical breeding areas or nests are disturbed. Positive effects can also occur if beach nourishment increases the area available for beach-nesting birds.

Noise from beach nourishment operations may affect birds that are nesting or feeding in the area by disrupting such activities for brief or extended periods of time. The severity of such disruptions would be different at each location depending upon the time of year and species involved, and impacts can only be assessed on a species- and site-specific basis. The frequency, duration, and intensity of the noise disturbance would all factor in to determining the effect upon birds in the area.

3.4.3.4 Threatened and Endangered Species

Sea Turtles

The only sea turtle which nests with any sort of regularity in the project area is the loggerhead. The other species of sea turtles rarely nest north of Georgia. Loggerheads rarely nest north of Virginia, making the chance of encountering a sea turtle nest throughout much of the project region unlikely. However, the potential does exist, particularly in Virginia. In 1998, a loggerhead false crawl (a foray onto the beach that does not result in a nest) was documented on the Maryland side of Assateague Island (S. Ramsey, Assateague National Park, pers. comm.). In Virginia, up to 10 loggerhead nests per year are documented on oceanside beaches from Cape Henry to the North Carolina Border, including Dam Neck and those on the Back Bay National Wildlife Refuge at the head of the Outer Banks. Back Bay NWR documented 2 loggerhead nests on its beaches in 1998 (L. Johnson, BBNWR, pers comm). The Assateague NWR in Virginia typically documents about one loggerhead nest every three to five years (S. Ramsey, pers. comm.). Anecdotal evidence from the mid-1980's cites a loggerhead false crawl on a Delaware beach (E. Stetzar, DNREC Stranding Network, pers. comm.). In New Jersey, a loggerhead nested in Ocean City in the mid- 1970's, and other nesting areas have included Little Beach Island, located between Brigantine and Long Beach Island, Island Beach State Park, and Seaside Heights. Most of these nestings occurred in mid to late summer. The nesting season for all sea turtles is generally from May through September.

Beach nourishment activities can result in sand compaction, which negatively affects nest site selection and may discourage nest placement by sea turtles (FPL 1992). The process of pumping, trucking, and depositing sand can disrupt nesting females and bury nests (NRC 1990). The use of heavy equipment, artificial lighting, and increased human activity related beach nourishment activities discourages nesting females and disorients hatchlings, which may be crushed by vehicles on the beach (NRC 1990). Studies have shown that nourished beaches are also harder than natural beaches. Beach hardening can also affect nest excavation and structure as well as emergence from the nest by hatchlings (Mortimer 1995; Ackerman 1996). Nourished beaches have a tendency to erode and form vertical escarpments that can prohibit upper beach access by nesting turtles (Ackerman 1996; Lutcavage *et al.* 1996). Studies have shown that nourished beaches retain more water than natural beaches, which can impede gas exchange in the nest chamber, and have greater thermal conductivity than natural beaches, which can affect the temperature-dependent sex ratios of nestlings (Mrosovsky 1995; Ackerman 1996).

Birds

Federally-listed birds in the project region are the piping plover and roseate tern. However, roseate terns are extremely rare in the mid-Atlantic region and are not known to nest in the area, so impacts to this species would be both unlikely and insignificant. State-listed (or special concern) birds that could be affected by beach nourishment activities are least tern (NJ, VA), Caspian tern (VA), gull-billed tern (VA), sandwich tern (VA), black skimmer (NJ), brown pelican (DE, VA), Wilson’s plover (MD, VA), and American oystercatcher (MD).

All of the aforementioned species of birds are beach nesters that utilize a bare substrate for their nests, making them particularly vulnerable to human disturbance and predation. Terns and skimmers are colonial, whereas the remainder are solitary nesters. Nesting success occurs when and where predator access and human disturbance are minimal. Beach-nesting waterbirds have suffered a significant loss of nesting habitat on a regional scale due to loss of beach habitat to human development and activity, but foraging habitat is abundant (USACE 1998a).

Beach nourishment activities can impact these species in a number of ways. Sand placement can bury nests, and machinery on the beach can crush eggs, nestlings and adults. Disturbance due to increased human activity, noise, and lights can disrupt nesting success. Positive effects may occur if beach nourishment increases the area available for nesting, although the substrate may not be suitable.

Any disturbance to federally-listed species, namely the piping plover or roseate tern, may be considered harassment and a potential “take” as defined in the Endangered Species Act. While roseate tern nesting has not been documented in the study area, piping plovers are known to nest throughout the mid-Atlantic region and significant efforts have been made to identify and protect critical habitat for this species. Loss and degradation of habitat due to development and shoreline stabilization have been major contributors to this species' decline (USFWS 1995a). Beach nourishment activities have the potential to degrade early successional beach habitats that are favored by piping plovers and other rare beachstrand species (USACE 1998a). Any beach nourishment activities in potential piping plover habitat would be subject to Section 7 consultations with USFWS.

Plants and Insects

Prime habitat for threatened insect or plant species, such as beach tiger beetles or seabeach amaranth, could also be disrupted by sand placement. Deeply burying the seeds or plants of seabeach amaranth could have serious effects on populations. On the other hand, beach replenishment rebuilds habitat for seabeach amaranth and other species, and can have long term benefits. On one beach in North Carolina, dredge spoil placement has apparently aided the reestablishment of this plant species (USFWS 1995b).

In the project region, seabeach amaranth is known from North Carolina, but populations of this species are primarily south of Cape Hatteras. These occurrences are outside the project area under consideration, so the likelihood of encountering a population of seabeach amaranth is remote. Beach tiger beetles, however, are present in several locations in Maryland and have been reintroduced to New Jersey. These locations must be given prior consideration when selecting areas for beach nourishment.

The federally-listed species that is most likely to be affected by beach nourishment activities in the project region is the piping plover. Piping plovers are known to nest throughout the mid-Atlantic region and significant efforts have been made to identify and protect critical habitat for this species. Loss and degradation of habitat due to development and shoreline stabilization have been major contributors to this species' decline (USFWS 1995a). Beach nourishment activities have the potential to degrade early successional beach habitats that are favored by piping plovers and other rare beachstrand species (USACE 1998a). It is reasonable to expect that beach nourishment would not be permitted in areas known to harbor piping plovers or prime piping plover habitat without prior consultation with USFWS and the appropriate state agencies.

3.4.4 Socioeconomic Environment

3.4.4.1 Archaeological and Cultural Resources

In the beach and near-shore sand placement areas, potential impacts to cultural resources could be associated with the placement and compaction of sand during berm and dune construction. The potential impacts to archaeological and cultural resources in a nourishment area will need to be addressed on a site-specific basis. However, it is likely based on previous projects conducted within the study area that the potential for impacts is very low. The beach and near-shore areas are located in a highly unstable and dynamic physical environment. The likelihood of intact and undisturbed cultural resources is considered extremely minimal.

3.4.4.2 Infrastructure

The placement of sand on an eroding beach would provide a positive benefit to adjacent coastal infrastructure, such as roads and municipal water and sewer systems, by offering additional protection from wave damage and flooding during storms. For example, for the 15-mile stretch from the Townsend’s Inlet to Cape May Inlet area of New Jersey, the USACE (1997a) estimated that, without the proposed beachfill and periodic nourishment, the annual infrastructure damage could exceed $165,000,000.

3.4.4.3 Recreation/Tourism

The aesthetic and socioeconomic benefits of beach replenishment outweigh the negative impacts. As noted above, the lack of beach replenishment would result in continued shoreline erosion, increasing the risk of residential property damage from storm, coastal flooding, and wave action. Subsequently, property values could decline as the potential impacts arising from a decreased beachface gained public awareness. Loss of beach could also inhibit recreational opportunities, successively linking decreases in tourism revenue and employment prospects.

Tourism and associated recreational activities generate a large portion of revenue for the coastal regions of the Mid-Atlantic Bight and their corresponding local communities, cities, counties, and states. The protection and replenishment of eroding coastlines is vital to continued economic prosperity for each area and it can initiate economic growth. The seasonality of population influxes to the coastal areas is determinant not only on meteorological events but is also affected by beach size and the availability of social services and accommodations. These communities depend on return, repeat visitation from non-local patrons. If the beach is noticeably decreasing in size, the return ratio of tourists can decrease with it. The increase to beach size will also improve recreational opportunities by creating more accessible land area for the pursuit of leisure activities (*e.g.,* surf fishing, sun bathing, etc.).

The expenditure of federal and state tax dollars for beach nourishment projects has also generated controversy due to the restricted public access in some beach communities. This has become a contentious issue in several communities within the study area, particularly along the northern New Jersey shore.

3.5 Cumulative Impacts

Cumulative impacts are defined by the Council on Environmental Quality (CEQ) as "*…effect on the environment which results from the incremental impact of the action when added to other past, present and reasonably foreseeable actions regardless of what agency or person undertakes such other actions. Cumulative effects can result from individually minor but collectively significant actions taking place over a period of time.*" (CEQ – Regulations implementing NEPA, 40 CFR 1508.7, 1508.8, 1508.25). There are a number of ways in which cumulative effects may originate (NRC 1986). These include:

- *Time crowded perturbations* – repeated occurrence of one type of impact in the same area;
- *Space crowded perturbations* – a concentration of a number of different impacts in the same area;
- *Synergisms* – occurrence of more than one impact whose combined impact is greater than the sum of the individual parts
- *Indirect impacts* – those caused by, produced after, or away from the initial perturbation
- *Nibbling* – a combination of all the above taking place slowly and incrementally or decrementally.

With dredging offshore areas for beach nourishment sand, there will be a concern for potential cumulative impacts as a result of repeated dredging in borrow within short periods of time such that the benthic community, in particular, does not have sufficient time to recover. In addition, dredging areas close to one another may result in impacts to potential adult recruitment to the dredged area, further lengthening recovery time. Cumulative impacts will need to be considered and addressed during any proposed beach nourishment project.

The potential cumulative impacts of dredging operations for beach nourishment will need to be examined in light of other activities in the immediate dredge area and surrounding area. These will include commercial fishing, dredged material disposal operations, military activities, and other activities which disturb the benthic community and which indirectly impact organisms which utilize the benthos as prey. Cumulative impacts could have an economic consequences if they affect commercially important species such as surfclams. In addition, the potential cumulative impacts on physical processes, such as the potential replenishment of shoals through natural processes, should be addressed.

Oakwood Environmental Ltd. (1998) prepared documentation examining the cumulative effects of marine aggregate mining in the United Kingdom. They discuss the development of temporal and spatial boundaries and a determination of resource threshold to impact which will be required to properly assess potential cumulative impacts.

4.0 MITIGATION MEASURES

4.1 Introduction

The U.S. Council on Environmental Quality (CEQ) regulations (40 CFR 1508.20) define mitigation to include: (1) avoiding the impact altogether by not taking a certain action or parts of an action; (2) minimizing impacts by limiting the degree or magnitude of the action and its implementation; (3) rectifying the impact by repairing, rehabilitating, or restoring the affected environment; (4) reducing or eliminating the impact over time by preservation and maintenance operations during the lifetime of the action; and (5) compensating for the impact by replacing or providing substitute resources or environments (CEQ 1978). Mitigation measures are either institutional in that they are inherent in project alternative selection, or as measures incorporated into the construction and operation and maintenance of the project. Dredging sand from federal waters for beach nourishment can be viewed as a mitigation measure which is employed to avoid and minimize potential impacts to the beach as a result of dredging sand too close to the beach.

Mitigation techniques can include operational measures or technology-based methods. They can be short-term or long-term and may be designed to avoid completely, minimize, remediate, or compensate for environmental impact. For the purposes of this report, mitigation is defined as the actions needed to reduce to the maximum extent possible, the effects of sand dredging and beach nourishment on the environment.

Recently, MMS (1996) provided a report on the mitigation techniques and considerations associated with offshore sand dredging. Specific mitigation measures will be driven by site and project specific requirements and constraints including:

- the location (including distance from the beach nourishment site and water depth) of the sand resource,
- the characteristics of sediments,
- the amount of sediment to be excavated, and
- the dredging technology to be used.

MMS (1996) outlined possible mitigation actions/requirements to an offshore dredging operation, including:

- avoidance through location-based, time-based, or scale-based constraints on dredging,
- minimize unavoidable impact through restrictions on dredge discharges and operating techniques,
- to remediate environmental impact through post-dredging activities,
- compensate for impact through alternative enhancement of a similar or related environment.

As discussed in Chapter 3 – Impacts, the main physical effects of dredging for sand on the continental shelf are suspended sediment/turbidity, distribution of sediment outside the dredge footprint, and changes in seafloor topography and geology/lithology. The main biological impacts are to the benthos and potentially to commercial fisheries, marine mammals, and sea turtles.

The following sections discuss mitigation measures as they apply to the offshore dredging and the placement of sand on the beach and nearshore areas.

4.2 Offshore Dredging Operations

4.2.1 Avoidance

To avoid potential impacts to sensitive resources or conflicts with other uses such as submerged cables or military areas, dredging can be prohibited in identified areas or within specified distances of the sensitive resource or user. In addition to spatial restrictions, avoidance can include the prohibition of activities at certain times of year.

Locations

Specific locations will need to be avoided to prevent interference with resources such as submerged communication lines, archaeological/cultural resources, military use areas, EFH, and commercially important fish grounds. In addition, borrow sites will need to be located in areas with minimal potential impact to the nearshore wave regime and longshore sand transport system.

Environmental Windows

Temporal constraints for various marine activities are utilized to establish protective windows around life cycle events for selected species potentially impacted by a proposed operation (MMS 1993). These "environmental windows" are based on the premise that potential impacts to a biological resource can be avoided and detrimental effects prevented by suspending dredging and nourishment operations during critical times when biological resources are most sensitive to disturbance (Dickerson *et al*. 1998). Spawning periodicity and the migrational seasonality of diadromous fish are not only important when considering implementation of temporal constraints on dredging activities; but they are also important to future stock survivability of a viable resource. Species recruitment and juvenile and larval migrations are extremely sensitive periods in the development of future stock assemblages. Dredging and renourishment operations should be limited to times and when potential impacts to these species is minimal to all life stages. In many instances, however, compliance with these windows can cause contractual complications and reduce project cost-effectiveness (Dickerson *et al*. 1998). Both the environmental issues and the economic issues need to be addressed and time frames developed in consultation with NMFS and should be based on site specificity.

In order to minimize the effects of dredging on plankton and larval fish populations, dredging should take place during times of year when primary and secondary production are low or when organisms are not at peak recruitment densities (*i.e.*, late fall through late winter). These times may not coincide with optimal dredging and placement times due to weather constraints.

Impacts to a potential borrow area can be minimized by first considering whether or not the community that is present is unique or of particular significance to the ecology or economy of the shelf area. If the resident community is of importance, it may need to be avoided. Timing and duration of dredging to coincide with intervals of low abundance and low diversity of organisms will also minimize potential impacts to an area.

Potential impacts to fish can be minimized by timing dredging efforts to avoid intervals when species are known to be migrating or spawning in a given area. The occurrence of life history stages of important commercial and recreational fish and shellfish within the project area are provided in Tables 2-13 and 2-14 in Chapter 2, respectively. Areas known to have a high concentration of commercial or recreational fishery activity should also be avoided to prevent disruption to the commercial or recreational fishery harvest. This will prevent disturbances in fishing methodology and minimize negative impacts to potential catch yields. Another alternative for minimizing potential impacts is through use of environmental windows.

Scales

The quantity of material dredged per day, per month or per year can be controlled to avoid potential impacts to the local current and wave regime as well as biological community This may be accomplished by specifying maximum size or capacity of a dredge or limiting the number of vessels or operations in a given area (MMS 1993).

4.2.2 Impact Minimization

Dredging operations will result in some environmental impact. To minimize or reduce impacts, consideration should be given to the following:

- use of appropriate and best technology,
- impose restrictions on certain operating practices, and
- require that certain procedures and equipment be employed for dredge discharges.

The use of trailing suction dredges, which interfere much less with bottom fisheries than do anchored suction dredges, can reduce potential conflicts with commercial fisheries (Drinnan and Bliss 1986).

Dredge course planning such as rotating the use of dredging sites can minimize potential impacts to the benthic community (see discussion in Section 4.2.3 below).   Also, boundaries can be established for sensitive resources in order to minimize potential impact . For offshore shoal areas which may be used as potential borrow sites, dredging could be planned in relation to shoal migration if there is a need to maintain the bathymetric character of shoal such that its value to marine life is not diminished (*e.g.*, to finfish which might orient to the bathymetric relief of the shoal).

4.2.3 Remediation

Remediation techniques have been rarely applied to offshore dredging operations for beach nourishment projects. A remediation technique that could be utilized if severe bathymetric changes occur as a result of the dredging operations is bed leveling. The seafloor is smoothed by devices towed over the seabed following the passage of a dredge. In addition, the area could be redredged to remove erratic topography caused by the previous excavation. The drawbacks are that the seafloor will never be returned to its original state and the action could cause additional environmental impact.

4.2.4 Mitigation Measures by Resources Affected

Bathymetry and Lithology

The magnitude of potential impact will be diminished if the amount of material removed constitutes a small percentage of a borrow area's total volume (USACE 1998a). Dependent upon the volume of material required for a particular project, it may be appropriate to use a mix of borrow sites to avoid significant disturbances to the dynamics of the system. The use of sites should be prioritized to minimize impacts.

Monitoring of borrow areas will be an important component in minimizing the impacts to the system. Of particular importance will be documenting any changes in the erosion and sedimentation/accretion patterns.

Current Patterns and Circulation

Borrow areas should be selected to minimize potential changes in coastal wave environment (i.e., wave height, breaking wave angles, and associated longshore transport). This can be determined through wave modeling efforts (*e.g.*, REF/DIF S) of potential sites similar to that which has been applied to the Sandbridge Shoal area off Virginia Beach, Virginia (MMS 1998).

Water Quality/Turbidity

As discussed in Section 3.3.2.4, the principal impact on water quality during offshore dredging operations will be turbidity. Turbidity levels will be directly related to:

1) the characteristics of dredged material (i.e., grain size distribution, etc.),
2) the type of dredging operations (i.e. cutterhead suction or hopper dredges), and
3) waves and currents at the location of dredging operations.

Of the three factors, site characteristics and dredging techniques are subject to some control and therefore mitigation measures can be taken to minimize turbidity levels.

- Control of Characteristics of Dredged Material

Dredging in sediments with high silt or clay content are the principal causes of high turbidity levels. Since these sediments are also undesirable beach fill material, a strict program of source control, that is, only dredging material suitable for the project, will not only prevent high levels of turbidity from occurring, but will make economic sense. The first step in any offshore sand mining project should be a thorough evaluation of the potential sand borrow areas both for suitability of the material as an end product and also from the stand point of predicting the level of turbidity generated during the dredging and/or emplacement operations.

- Mitigation During Dredging Operations

Sediment resuspension (turbidity) levels vary from dredge to dredge and largely depend upon the dredging technique adopted (Herbich 1992).

<u>Cutter Suction Dredges</u>

In the case of cutter suction dredges, turbidity is generated by the rotating action of the cutter and the swing action of the ladder, the impact and removal of dredge spuds, the movement of anchor and side wires and leakage from discharge pipelines.

Turbidity can be reduced by selection of the cutter type for a given sediment and operating at the correct relationship between the rotational speed of the cutter and the magnitude of the hydraulic suction applied to the dredge pipe. Turbidity can also be reduced by the addition of a hooded shield placed over the cutterhead. A hood device helps to improve capture of resuspended sediments by the suction action of the dredge. However, the turbid waste captured by the dredge will have to be discharged either in a loading barge or directly on to the beach. Leakage from discharge pipelines can be reduced by use of proper fittings, ball joints or flexible connections between pipe sections.

<u>Hopper Suction Dredges</u>

Sediment resuspension in hopper suction dredging operations is caused by:

1) movement of the draghead along the seabed;
2) the overflow of the hoppers during loading and on completion of loading;
3) action of waterjets fitted to draghead (if used);
4) blockages of the suction pipe requiring the pipe to be emptied and,

5) dumping through bottom hoppers (if bottom dumping is used as the discharge method).

It is generally recognized that the single greatest contributor to turbidity generated by hopper suction dredges is caused by the overflowing of hoppers during loading. The turbidity caused by the dragheads is low compared to that of the overflow and is generally accepted as negligible.

Overflow mitigation for hopper dredges is described in detail in the MMS 1996 report, pages 132 – 134. A summary of these sections follows.

- Overflow Mitigation: Operational Technique

A practical mitigative technique is to delay the commencement of hopper overflow. This is achieved by emptying all water out of the hopper before pumping any sediments on board. Water is discharged directly overboard as the dredge pump is primed. A switching mechanism is then used to direct the slurry to the hopper once sediments are entrained in the pumping system. As a result, overflow does not occur until the hopper is filled to within 60 to 70% of its dredged material capacity. The time during which sediment- laden waters are released to the sea is thereby substantially reduced.

Dredge sediment quality can be judged visually. However, the installation of a drag-head sensor automatically coupled to a voiding valve immediately down-flow from the pump would result in major advantages (Nunny and Chillingworth 1986). Poor quality dredge feed could be recognized and diverted more rapidly. Both contamination of the loaded sand and high silt overflow would thereby be reduced.

- Overflow Mitigation: Recycling

Tile drag-heads of some trailing suction hopper dredges are equipped with water jets that are designed to assist in the liberation of compacted sediments when dredging hardground (see Section 3.3.1.2.2). A small percentage of the hopper overflow water can be pumped to the drag-head jets instead of using clean seawater, reducing slightly the total volume of sediment-laden overflow.

In Japan, a system has been developed whereby all the turbid overflow water from the hopper is recycled to the drag-head intakes. This system improves efficiency by increasing the density of the sand slurry (Ofuji and Ishimatsu 1976). The concentration of suspended particles is reduced, and the transparency of hopper overflow water is increased after the installation of such an anti-turbidity system. An inherent problem with this technique is that the overflow water continually recirculates in a closed loop. The slurry becomes increasingly laden with silts and clays until it attains a density beyond the capabilities of the dredge pump. The benefits are therefore short-term since the only solution is to purge the system at intervals. Short duration discharges of high density effluent are produced, as opposed to a more continuous dilute overflow, with a minimal overall net benefit.

- Overflow Mitigation: Hopper Design

The level of the surface in a loaded hopper always must be above the load line in order to prevent surplus water from being transported to shore in addition to the solids. This can be achieved by modifying the shape of the hopper to keep much of the contents above the load line. Alternatively, special compartments may be employed on either side of the hopper.

Other developments include deeploading and semi-deeploading systems. The purpose of these systems is to reduce the amount of energy required to load the hopper and to limit the volume of air in the supernatant water passing to the overflow. A reduction in the turbidity of the overflow water, and thus that surrounding the vessel, also can be achieved by means of an anti-turbidity valve which can be installed in the IHC telescopic, cylindrical overflow weir.

Several methods for increasing solids concentration in the hopper are in the experimental stage and represent examples of how environmental mitigation simultaneously improves the economics of the dredging operation. They include the use of:

(1) slurry feed diffusers to reduce turbulence in the hopper and to enhance the settling of suspended sediments;

(2) centrifugal separation (hydrocyclones) to dewater the solids; and,

(3) inclined plates in the hopper to increase the settling rate of the slurry suspension.

- Overflow Mitigation: Overflow Collection

An anti-turbidity measure for hopper dredging is to install compartments on both sides of the dredge. These are designed to intercept and temporarily retain the overflow, allowing partial settling of suspended silts within them. However, the following disadvantages of this approach are all potentially serious, practical, limitations:

(1) the retention time needed for substantial settling to occur;
(2) the need, at intervals, to dispose of the accumulated silts;
(3) the significantly reduced hopper capacity caused from the loss of vessel space by incorporating settling compartments.

- Overflow Mitigation: Effluent Discharge

A relatively simple technique for handling hopper overflow, called an anti-turbidity overflow system (ATOS), has been developed in Japan (Nunny and Chillingworth 1986). The overflow collection system is streamlined to minimize the entrapment of air bubbles in the overflow water. Removal of the air bubbles, which otherwise make the particles buoyant and prolongs settling, allows the fines to settle at a faster rate. This system has been successfully applied to TSH dredges off the coast of Japan. In addition, the overflow discharge ports are moved from the sides of the vessel to the bottom of the dredge's hull (Raymond 1984). Discharged particles descend rapidly in the water column with a minimum amount of dispersion.

Benthos

The majority of unavoidable impacts from the dredging operations will be to the benthic community.

Impacts to a potential borrow area can be minimized by first considering whether or not the community that is present is unique or of particular significance to the ecology or economy of the shelf (*e.g.*, offshore of southern New Jersey). If the resident community is of importance, it may need to be avoided. Timing and duration of dredging to coincide with intervals of low abundance and diversity of organisms will also minimize potential impacts to an area.

Sand sediments constitute a significant proportion of the habitat on the continental shelf. Over 259 sand ridges have been identified on the inner continental shelf (< 20 m) along the East Coast of the U.S. (Able and Hagen 1995). In order for a sand area to be considered a unique habitat it would have to have a very high abundance and diversity of species, with some particular species that are not located in equal abundances elsewhere in the Bight. One such area, located within the current study area, is located off the coast of southern New Jersey (Figure 2-81). This area supports one of the most abundant and diverse marine communities on the east coast of the U.S. (Wigley and Theroux 1981), as well as the most productive surfclam fishery in the U.S. Potential borrow sites in this region should be assessed very carefully, on a site by site basis, before sand mining is permitted. The potential borrow areas located in New York, Delaware, Maryland, and Virginia are not located in areas of particularly high species abundance and diversity. While these locations may be ecologically or economically important, they may not be unique marine communities that would need to be avoided when selecting borrow areas.

Measures to minimize potential effects of dredging in a borrow area or areas include dredging in a manner to avoid creation of deep pits, alternating locations of periodic dredging, and conducting dredging during months of lowest biological activity.

The USACE (1998d) reported that a February/March dredging cycle would occur slightly before a natural spring season benthic recruitment peak. Repopulation of the benthos was expected to occur rapidly after the spring placement operation as the natural cycle of recruitment and growth is high during this period. In contrast, if an October/November dredging occurred it was expected that benthic repopulation would be slower due to the lower rate of recruitment at this time of year. Benthos from adjacent non-disturbed areas would be expected to repopulate the disturbed areas at both times of year.

To minimize repeated impacts to the benthos within a borrow area, each renourishment phase of a project could be conducted in a limited portion of the borrow area and locations could be alternated for each subsequent renourishment cycle. Rotational dredging minimizes frequent, repeated disturbance of a particular area, thereby allowing recolonization of benthic organisms to occur over a longer period of time.

Implementation, in association with an Environmental Impact Statement, of a benthic monitoring program concurrent with the project would document impacts and aid in avoiding impacts to sensitive areas.

Marine Mammals

As described in Chapter 2, several species of marine mammals occur throughout the project area including several protected/listed species of whale which occasionally travel through the project area. Non-listed species that may be encountered include harbor seal, harbor porpoise, bottlenose dolphin, common dolphin, spotted dolphin, minke whale, and pilot whale. Endangered whales that may frequent the project area are blue, fin, humpback, right, and sperm whales. As was discussed in Chapters 2 and 3, the continental shelf off the Delmarva peninsula in the Chesapeake Bay region harbors the greatest concentration of marine mammals in the mid-Atlantic, particularly during the spring and summer months. Mid-shelf east of the Chesapeake Bay region is a high use habitat for marine mammals, with piscivorous species generally concentrated off the coasts of Delaware and Maryland during these seasons (Kenney and Winn 1986). Figure 2-83 in Chapter 2 depicts the seasonal concentrations of the most commonly found whales, namely the fin, sperm and humpback.

Location and timing of an offshore dredging operation are critical factors for determining the impacts caused by noise. Noise from dredging activities located away from known migratory pathways, breeding and foraging areas, or from activities conducted during off-peak seasons, namely fall and winter, are unlikely to adversely affect marine mammal populations, although individual transient animals near dredging sites may be startled or show avoidance behavior (MMS 1993). Collisions with marine mammals can be eliminated or significantly minimized by requiring or encouraging reduced boat speeds in areas known or suspected concentrations of these animals or when animals are sighted in the vicinity of a vessel. In addition, restricting dredging to daylight hours will minimize the risks of strikes. In addition, NMFS-approved whale spotters/observers should be stationed on the dredger to minimize the risk of ship-strikes of whales. As was discussed in Chapter 3, right whales are particularly susceptible to vessel collisions, due to their surface-feeding habits.

Sea Turtles

Sensitivity to the location of sea turtle migratory pathways, high use habitats and seasons is important when determining the timing and location of offshore dredging operations. Figure 2-83 in Chapter 2 depicts when and where high concentrations of loggerhead and leatherback sea turtles occur. For other species, spring and summer in the Chesapeake Bay area are also high use times of year.

The risk of entraining and injuring or killing sea turtles in a dredge can be minimized by the selective use of, and modifications to, dredging equipment and methods. Coordination with the NMFS will be required. Typically, the use of properly installed and operated approved sea turtle deflectors (*e.g.*, WES designed diamond shaped deflectors) to minimize significant adverse impacts to sea turtles in the area and use of NMFS approved observers to monitor dredge operations would minimize potential impacts. For a U.S. Army Corps of Engineers (Baltimore District) dredging project in the Chesapeake Bay, it was suggested that future dredging operations occur only in the winter due to the high occurrence of sea turtles in the area (M. Mendelson, USACE, pers. comm.). Proper training of dredge operators is also very important, because the dredge arm needs to be kept as close to the bottom as possible to avoid entraining most turtles (M. Mendelson, USACE, pers. comm.).

In areas where sea turtle nesting occurs, mitigation techniques must be used during beach nourishment activities. Consultation with USFWS, NMFS and the appropriate state agency will be required, and any proposed mitigation techniques are subject to agency approval. It is suggested that nourishment take place in late fall or winter, when turtles are not nesting. If sand placement is to occur on a turtle nesting beach, the quality of nourishment material must be acceptable. Some nourished beaches have a high clay, silt, and shell content that is too compact and coarse for nest excavation (Lutcavage *et al.* 1996). A substrate must facilitate gas diffusion and must be moist and fine enough to prevent collapse of the egg chamber (Miller 1996). Beaches with deep, loose sand facilitate nesting success. If beach nourishment activities do take place during the nesting season, activities should take place only during the day. Qualified persons (approved by USFWS/NMFS) should patrol the beaches for nests, nesting turtles, or hatchlings concurrent with nourishment activities. Any nests should be marked so as to prevent sand placement on top of the nest. If known, the date that the nest was laid should be indicated so hatching can be anticipated (average 55 day incubation period). If work takes place at night, lighting should be diffuse (such as intermittent lighting or red lights) to help avoid confusing nesting females or hatchlings (J. Wilson, MMS, pers. comm.). Beach slope design should be engineered to avoid erosion that will result in the formation of vertical escarpments.

Commercial Fisheries

Areas known to sustain high concentrations of fishing activity should be avoided when practicable. This, in turn, will prevent disturbances in fishing methodology and minimize negative impacts to potential catch yields. Potential impacts could be minimized by timing dredging efforts to avoid intervals when species are known to be migrating or spawning in a given area (Table 2-14) (Olney *et al.* 1998). Areas known to have a high concentration of fishery activity should also be avoided to prevent disruption to the commercial or recreational fishery harvest. Another alternative for minimizing the inevitable effects between the biological and socioeconomic impacts to commercial and recreational fisheries from dredging activities is through the utilization of environmental windows (Ault *et al.* 1998). The term *environmental window* defines temporal constraints placed upon dredging operations to minimize the deleterious effects to biological resources and their corresponding habitats (Dickerson *et al.* 1998). Since the study area is vast and bathymetry varies with geography, each potential borrow site should be assessed individually to determine regularity and seasonality of fishing, benthic biodiversity, targeted species population densities, biomass, and distribution before the area is utilized and to determine necessity, periodicity, and duration of any environmental windows. These assessments should be conducted seasonally to insure minimal effects to the varied biological communities and to the recruitment of future stocks.

Of particular concern with the New Jersey portion of the project area is the potential adverse impact of dredging on commercial surfclam areas. In 1997, surfclam landings represented 67% of New Jersey's total mollusk landings and 84% of the landings for the combined Mid-Atlantic and New England surfclam harvest total (J. Normant, NJDEP, pers. comm., October, 1999). Surfclam harvesting in New Jersey is primarily conducted from the Shrewsbury Rocks to the southern regions of Cape May. Yet, harvest locations vary seasonally from Point Pleasant south to Cape May based on weather, cost-effectiveness, fleet location, and the quality of the clams being harvested (Jeff Normant, NJDEP, pers. comm., October, 1999). Utilization of borrow sites for dredging operations along the New Jersey coastline should be individually assessed to minimize any impacts. Commercial surfclam areas should be omitted from the selection processes of potential borrow sites. Benthic surveys should be conducted to determine current population abundances and size variations. If viable commercial populations exist or if a future recruitment is evident within proposed borrow sites, measures should be taken to minimize potential impacts.

Archaeological/Cultural Resources

Utilize remote sensing to evaluate potential borrow areas for archaeological or cultural resources. To eliminate potential impacts to sites which are present, a buffer could be established around the site(s) in order to avoid disturbance. Coordination under Section 106 with the appropriate SHPO would need to occur.

4.3 Nourishment Operations

As described in Chapter 3 (Impacts), the resources potentially affected during placement of sand on the beach include: water quality/turbidity, nearshore benthos, birds, recreation, air/noise quality, and archaeological/cultural resources.

Water Quality/Turbidity

Because the sand placed on the beach will be mostly coarse-grained and beach areas have naturally high energy conditions, no measures are recommended to minimize turbidity impacts.

Nearshore Benthos

To minimize the potential impacts of beach nourishment on benthic organisms, the timing of nourishment projects and the sediment grain size placed on the beach should be considered. Nourishment projects should be coordinated with the months of lowest faunal abundance and diversity (approximately late November to early March). The sediment used to nourish the beach should closely resemble the grain size of sediments already on the beach.

Reilly and Bellis (1983) reported that larval recruitment appeared to be inhibited by the greater water turbidity associated with nourishment operations at a beach in Bogue Banks, NC. They recommended that the sand being placed on the beach should be selected to minimize turbidity and nourishment activities carried out before the onset of larval recruitment in the spring. In addition, small nourishment projects, of 0.8 km or less, recover faster than larger projects because the speed of recovery is dependent upon recruitment from nearby beaches. Therefore, a succession of small projects carried out in nonsequential order should have less long-term impact than a single large-scale project. However, these considerations would need to be weighed together with other constraints on the project.

Fish

To minimize these impacts, Hackney *et al.* (1996) recommend nourishing beaches from late November to early March to avoid higher fish densities, to avoid nourishing beaches with sediment of small grain size which would increase the impacts of gill clogging and abrasion, and to stagger the timing of multiple nourishment projects in the same area.

Birds

As described in Chapter 2, several bird species nest on beaches within the project area. Some common, non-listed species that nest in the area include the common tern, several sandpipers and plovers, and a variety of gulls such as herring gull and laughing gull. Beach nesting birds that are state-listed as threatened, endangered, or of special concern are Least Tern (NJ, VA), Caspian Tern (VA), Gull-Billed Tern (VA), Sandwich Tern (VA), Black Skimmer (NJ), Brown Pelican (DE, VA), Wilson's Plover (MD, VA), and American Oystercatcher (MD). Timing of operations to avoid nesting and hatching season (which for all of these species is spring and summer) is the best way to avoid potential impacts. If avoidance is not possible, some of the specific techniques described below for piping plover may be utilized as deemed appropriate for the situation. Birds that only use onshore habitats for feeding and resting are unlikely to experience significant or permanent impacts. Mudflats and tidal pools are some important feeding habitats for many shorebirds and should be avoided during nourishment operations.

Of particular concern within the project area is the Piping Plover which is Federally listed as threatened and nests on beaches within the project area. As described in the *Assateague Island Emergency Sand Placement Finding of No Significant Impact and Environmental Assessment* (USACE 1998b), potential impacts to the Piping Plovers include; construction vehicles crushing flightless chicks, fences increasing the vulnerability of flightless chicks to predators, habitat disturbed during construction inducing territorial interactions between individual plovers driven off the site, and potentially disturbing nests. Coordination will be required between the project sponsor and the USFWS and appropriate state agency (*i.e.*, NJ DEP Division of Fish, Game and Wildlife, MD Department of Natural Resources, etc.) and National Park Service, if the project is on their lands.

Direct adverse impacts to the piping plover can be minimized by implementing potential measures including: excluding piping plover from the construction site; requiring buffer zones around nests and foraging areas; and implementing a monitoring program for the construction site and vehicles. In addition, consideration of limiting construction in these areas to periods outside of the nesting season (1 April – 15 August).

To exclude piping plover from the construction area, plover may be ushered out of the project footprint and then a silt fence erected to exclude flightless chicks from reentering the area. The area could be monitored to ensure the integrity of the fence and its ability to exclude pedestrial plovers is maintained.

If nests occur within a potential project area within the time proposed for construction then options include altering the construction sequence, potentially working around nest areas while leaving a 100 to 200 m buffer, or postponing work until after all the eggs have hatched (approximately late July). If the area is determined to be a critical foraging ground, a buffer zone could be established to protect the area as foraging habitat. In addition, vehicles travelling to and from the construction site should be accompanied by a plover monitor to minimize the risk of crushing plover chicks. Construction equipment could also be deployed to the site by barge from the ocean.

Recreation

Beach nourishment operations typically occur within isolated segments, subsequently moving as work progresses. As each work segment is completed, it can be opened for recreational use. This would allow access for recreation in areas outside the segment under construction.

Air Quality

To reduce the air quality impacts of a proposed project resulting from dredging operations by utilizing heavy equipment in the specific area and at the beach, especially to reduce the critical air emissions nitrogen oxides (NO_x) during the project operations, a proposed project would need to implement all necessary mitigation actions to keep projected emissions at low levels. Project-provided control measures may include:

- Use of a cutter-suction dredge, instead of a hopper dredge. This method will result in lower emissions and keep most of the generated emissions at greater distances from shore.

- Use of upgraded low-emission engines or clean fuel equipments.

- Reduction of the dredging activities and relevant operations during the summer ozone season.

- If the project emissions exceed the conformity threshold at any operation sites, then the excess emissions induced by the project need to be either included in the appropriate State Implementation Plan for offset or reduced by re-scheduling the dredging operation and volumes until the allowable emission levels are reached.

Archaeological/Cultural Resources

Under Section 106, coordination should take place with the appropriate SHPO to determine the level of study required to document potential archaeological and cultural resources within a particular beach segment proposed for nourishment.

5.0 RELEVANT FEDERAL AND STATE REGULATIONS

The following Chapter provides an overview of the Federal and state regulations that pertain to potential users of OCS sand resources. The 1994 amendment to Section 8(k) of the Outer Continental Shelf Lands Act (OCSLA) (see below) authorized a negotiation process in lieu of competitive bidding when OCS sand resources are needed for certain public works uses, including shore protection, beach restoration and coastal wetlands protection (Appendix E). The amendment helps coastal states by providing a more appropriate mechanism for obtaining access to Federal sand, gravel, and shell resources for public works projects. Many shore protection projects are authorized by Congress and implemented by the USACE and state and local governments. In April 1999, the MMS and USACE signed a Memorandum of Agreement (MOA) establishing procedures for coordination and cooperation with respect to the use of OCS sand, gravel, and shell resources for USACE-authorized shore protection projects (Appendix E).

5.1 Federal Regulations

5.1.1 Outer Continental Shelf Lands Act

UNITED STATES CODE CITATION: 43 U.S.C. § 1331 et seq; 43 U.S.C. § 1801 et seq

MMS's authority to manage minerals on the OCS is contained in the OCS Lands Act (OCSLA) (43 U.S.C. § 1331 et seq.). DOI's jurisdiction for leasing and regulating the recovery of minerals extends to the subsoil and seabed of all submerged lands underlying waters seaward of state-owned waters to the limits of the Outer Continental Shelf (except where this may be modified by international law or convention or affected by the Presidential Proclamation of March 10, 1983 regarding the Exclusive Economic Zone). Section 8(k) authorizes the Secretary to convey resource development rights to any other mineral on the OCS other than oil, gas, and sulphur (43 U.S.C. § 1337(k)).

The 1994 amendment to Section 8(k) of the OCSLA (43 U.S.C. § 1337(k)(2), Public Law 103–426) reaffirmed the authority of the Secretary with respect to OCS sand, gravel, and shell and expanded this authority by allowing for negotiation of agreements for certain specified uses, in lieu of competitive cash bonus bidding. MMS developed policy and guidelines on assessing fees for OCS resources used for shore protection, beach restoration, and coastal wetlands restoration (under OCSLA Section 8(k)(2)(A)(i)) (MMS, October 1997). For other negotiated agreements, *i.e.*, when sand is requested for use in any other Federally funded or authorized construction project (under OCSLA Section 8(k)(2)(A)(ii)), fees will also be negotiated on a case-by-case basis. For competitive leasing under Section 8(k)(1), e.g., private use for commercial aggregate, MMS will establish terms and conditions at the time of offering the resources for lease. Section 8(k)(2)(B) provides discretion for establishing fees. Subparagraph (2)(B) specifically provides that a fee may not be assessed directly or indirectly against a Federal, state, or local government agency (H7282 – Congressional Record, House, August 5, 1999). As a result, when OCS sand is used for protection of Federally-owned land (*e.g.*, military bases, national parks, and refuges) a fee would not be assessed. There is no change in resource ownership when sand is transferred from the OCS to Federally-managed property. In addition, from H7282 August 5, 1999, any amount paid by non-Federal interests for beach erosion control, hurricane protection, shore protection, or storm damage reduction projects as a result of an assessment under Section 8(k) of the OCSLA (43 U.S.S. 1337(k)) shall be fully reimbursed.

MMS and the USACE have developed a MOA (April 21, 1999) which establishes procedures to assure timely coordination and cooperation between the two agencies as they carry out their responsibilities related to the use of OCS sand, gravel, and shell resources for USACE authorized protection projects. In addition to the exchange of information, after the environmental analyses for the proposed project are complete and a decision is made to use OCS sand, the MMS and the USACE will enter into a project-specific MOA as required by the OCS Lands Act. For those projects in which sand is transferred to a state or locality, the MMS will enter into a negotiated agreement with that state or locality. In those instances where the sand is being transferred to another Federal agency, the MOA will include the other Federal entity.

5.1.2 National Environmental Policy Act (NEPA)

UNITED STATES CODE CITATION: 42 U.S.C. § 4321- 4347

The National Environmental Policy Act (NEPA) is the basic national charter for protection of the environment. The Act declares it a national policy to "encourage productive and enjoyable harmony between man and the environment; to promote efforts which will prevent or eliminate damage to the environment and biosphere and stimulate the health and welfare of man; and to enrich the understanding of the ecological systems and natural resources important to the Nation" (42 USC 4321). The profound impacts of man's activities "on the interrelations of all components of the natural environment" are recognized (e.g., urbanization, population growth, industrial expansion, resource exploitation) (42 USC 4331). The Act specifically declares a "continuing policy of the Federal Government, in cooperation with state and local governments, and other public and private organizations to use all practicable means and measures to create and maintain conditions under which man and nature can exist in productive harmony, and fulfill the social, economic, and other requirements of present and future generations of Americans" (42 USC 4331).

The Act also states that it is the continuing responsibility of the Federal Government to use all practicable means, consistent with other essential considerations of National policy, to improve and coordinate Federal plans, functions, programs, and resources to, among other things: assure safe, healthful, productive and esthetically and culturally pleasing surroundings for all Americans; attain the widest beneficial use of the environment without degradation, risk to health or safety; preserve important historic, cultural and natural aspects of our national heritage; achieve balance between population and resource use which will permit high standards of living and a wide sharing of life's amenities; and, enhance the quality of renewable resources and approach the maximum attainable recycling of depletable resources (42 USC 4331).

The Act authorized and directed "that, to the fullest extent possible, the policies, regulations and public laws of the United States shall be interpreted and administered in accordance with the policies of the Act", and imposes general and specific requirements on all Federal agencies (42 USC 4332). Agencies are required to "utilize a systematic, interdisciplinary approach which will ensure the integrated use of the natural and social sciences and the environmental design arts in planning and decision making...". They are also to insure that "unquantified environmental amenities and values may be give appropriate consideration in decision making along with economic and technical considerations" (Section 102(2)(A)) (42 USC 4332 (2)(A)).

Section 102(2)(C) (42 U.S.C. 4332) requires that every recommendation or report on proposals for legislation and other major Federal actions significantly affecting the quality of the human environment include a statement on: the environmental impacts of the proposed action; any adverse environmental effects which cannot be avoided should the proposal be implemented; alternatives to the proposed action; the relationship between local short-term uses of man's environment and the maintenance and enhancement of long-term productivity; and, any irreversible and irretrievable commitment of resources which would be involved in the proposed action should it be implemented. Agencies responsible for the action shall consult with and obtain comments from other agencies with jurisdiction by law or special expertise, with response to any environmental impact.

NEPA also established the Council on Environmental Quality (CEQ), in the Executive Office of the President (42 USC 4341). The Council advises and assists the President in providing leadership in protecting and enhancing the quality of the Nation's environment. It develops and evaluates Federal policies and activities on environmental quality. One of CEQ's primary functions in relation to water resources is the preparation of regulations concerning the development of environmental impact statements developed by Federal agencies. The Office of Environmental Quality (OEQ), which was established in 1970, by the Environmental Quality Improvement Act, (P.L. 91-224) (42 USC 4371 et seq), provides staff for the Council.

NEPA requires that a detailed statement accompany every recommendation or report on proposals for legislation and other major Federal actions significantly affecting the quality of the human environment. A finding of no significant impact is prepared by the reporting officer to accompany an assessment when it is determined that an EIS will not be prepared. NEPA documentation is accomplished prior to implementation of emergency work, if practicable.

A notice of intent to prepare a draft EIS is published in the Federal Register as soon as practicable after reporting officers decide to prepare a draft EIS. A Record of Decision is prepared to document the final decision on a proposed action requiring an EIS. The Record of Decision identifies the reasonable alternatives; designates the environmentally preferable alternative or alternatives and the agency's preferred alternative; the relevant factors including economic and technical considerations, statutory missions, and national policy which were balanced to make the decision; and whether all practicable means to avoid or minimize environmental harm have been adopted, and if not, why not.

The Council on Environmental Quality developed Regulations For Implementing the Procedural Provisions of the National Environmental Policy Act (40 C.F.R. 1500-1508). Part 1500, Sec 1500.1(b) of this guidance requires that provisions must be made to insure that environmental information is available to public officials and citizens before decisions are made and before actions are taken. Section 1506.6 provides requirements for public involvement, requiring that ... agencies shall make diligent efforts to involve the public in preparing and implementing their NEPA procedures. These regulations go on to mandate that the general public be involved in scoping of the project, and be invited to comment after release of the draft EIS and the final EIS and responses to those comments are provided.

The Council on Environmental Quality (CEQ) regulations implementing the provisions of NEPA (40 C.F.R. 1500-1508) require the Federal agency having primary responsibility for preparing an EIS to determine whether any other Federal agencies have jurisdiction by law, a statutorily mandated consultative role, or special expertise on environmental quality issues. "Jurisdiction by law" is defined as authority to approve, deny, or finance all or part of a proposal, and encompasses permits and licenses. "Special expertise" is defined as statutory responsibility, agency mission or related program experience. Appendix II of CEQ regulations lists Federal agencies so defined.

Figure 5-1 depicts MMS actions for non-Federal agency OCS sand and gravel resources negotiated agreements. MMS will evaluate the proposed action and examine the potential for significant impacts associated with the action to determine if an EA or an EIS is required. An EA is a concise public document in which a Federal agency briefly provides sufficient evidence and analysis for determining whether to prepare an EIS or finds that the proposed action poses no significant environmental risk. An EIS is a detailed document that thoroughly analyzes the proposed action; an EIS is prepared when the Federal agency has determined that a major Federal action is being considered and that it is environmentally significant in scope and magnitude such that the potential impacts must be examined in greater detail.

In cases of NEPA significance, when the MMS has determined that the actions being considered are major and that significant environmental issues must be analyzed in-depth, area-wide, programmatic EIS's examining the environmental effects of dredging in identified borrow areas in specific geographic areas to support future negotiated agreements or project-specific EIS's may be prepared. After completion of an initial area-wide document, EA's to support noncompetitive leases, when requested, would be undertaken. In cases where NEPA significance does not exist, then an EA would be prepared. EA's may be prepared when a previous NEPA analysis which adequately covers the potential for impacts in the same area or is considered tierable under the NEPA regulations has been completed. In certain cases, the previous document can be adopted in whole, and the present decision can be based on the prior analysis.

Figure 5-1. MMS NEPA Responsibilities for Negotiated Agreements for OCS Sand and Gravel (Non-Federal Agency Project)

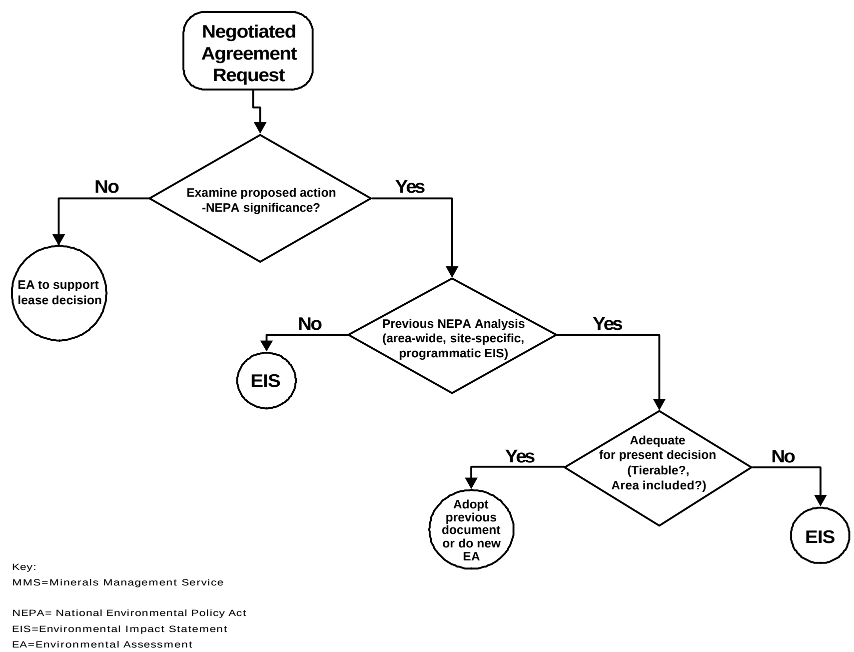
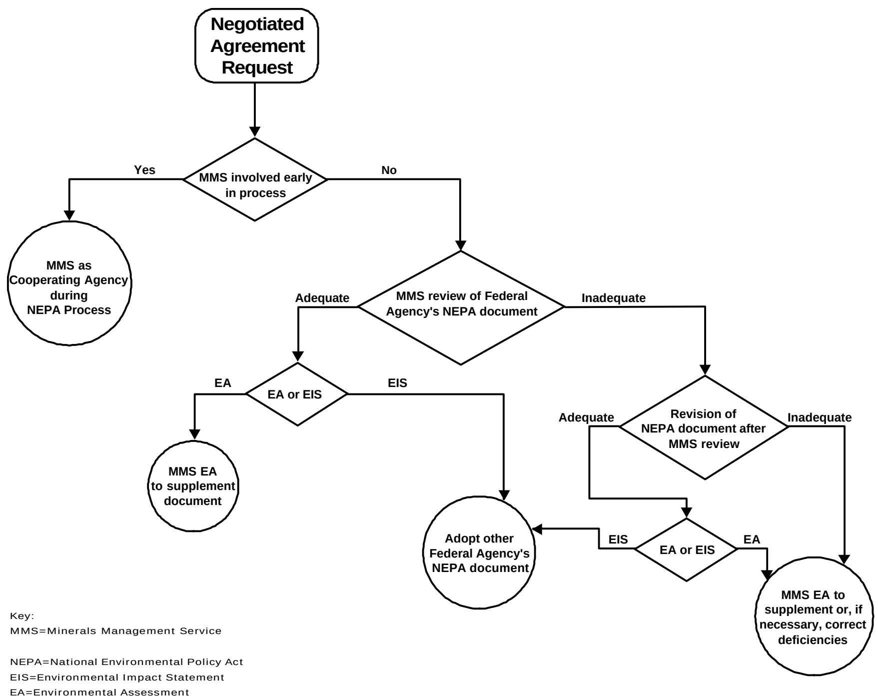


Figure 5-2 depicts MMS actions for other Federal agency OCS sand and gravel resources negotiated agreements. When a proposed project, for which the negotiated agreement is intended, is a Federal agency project that requires the use of Federal sand, then that agency normally will undertake the required NEPA analysis. In instances when the MMS is notified by the other Federal agency prior to initiation of the NEPA process, then the MMS would request cooperating agency status and prepare sections of the EIS that pertain exclusively to the use and transportation of OCS sand. The MMS would also participate in the Endangered Species consultation.

When an outside agency has prepared the NEPA analysis, whether it is an EIS or EA, the MMS must undertake a detailed review of the document to determine its adequacy for supporting a negotiated agreement. If the outside agency's document is an EIS found to be adequate, then the NEPA regulations allow the MMS to adopt the document. The MMS will place a notice in the *Federal Register* outlining the MMS position. NEPA regulations concerning adoption do not extend to EA's. Therefore, even if an MMS

review indicates that the other Federal agency's EA is adequate, the MMS must prepare its own EA to support the potential agreement.

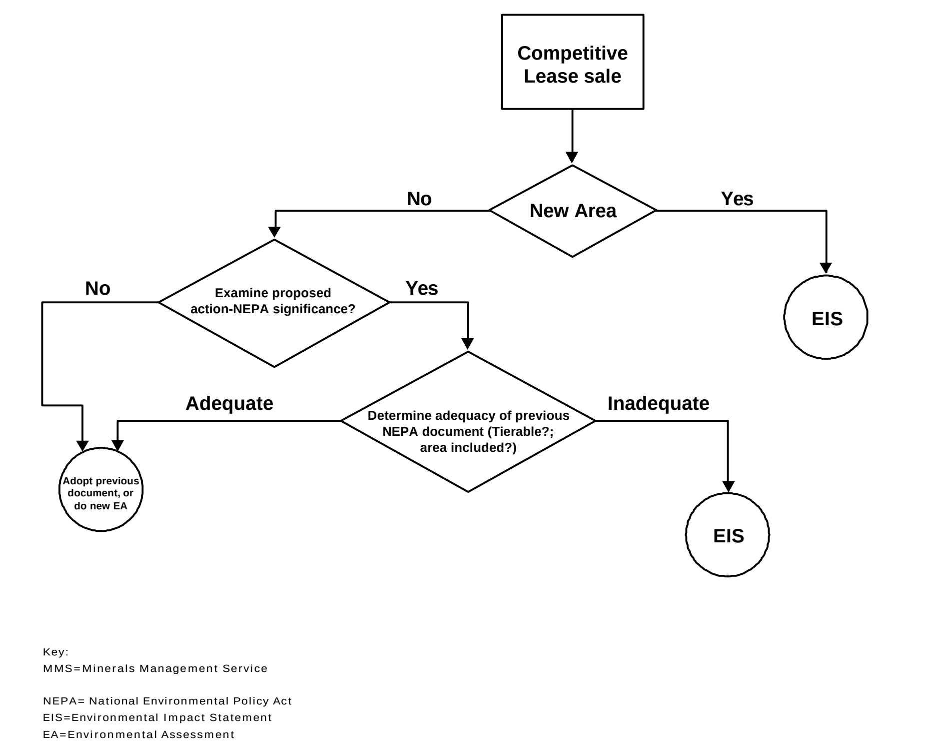
Figure 5-2. MMS NEPA Responsibilities for Negotiated Agreements for OCS Sand and Gravel (Federal Agency Project)



When an MMS review of a Federal agency's EIS or EA indicates that the analysis is not sufficient, then the MMS will (if the document is a preliminary or draft) send a detailed review letter outlining the inadequacies and detailing the revisions that should be made. If the document is an EIS and is revised accordingly, then the MMS would adopt the document as outlined above. If the revised EA is adequate, the MMS will prepare a short and concise EA to support the agreement. If the revised document, whether it is an EIS or an EA, is not sufficient, then the MMS would prepare a detailed EA correcting the defined deficiencies.

Figure 5-3 depicts MMS actions for Federal OCS sand and gravel resources for competitive lease sales. If the proposed sale is to be held in a new area for which a previous EIS has not been completed, then an EIS will be prepared. Should an EIS or other NEPA document exist, the MMS must determine its adequacy in light of the new decisions to be made, if it covers the area being considered for lease, or if it is tierable. If an EIS exists, but new environmental information is available, such that it would significantly affect the decision, then a new EIS would be prepared. If an existing EIS or NEPA material serves to support any new decisions, then the previous document would be adopted or a new EA would be prepared to supplement or support the previous analysis.

Figure 5-3. MMS NEPA Responsibilities for Competitive Hard Mineral Lease Sales



5.1.3 Coastal Barriers Resources Act

UNITED STATES CODE CITATION: 16 U.S.C. § 3501 et seq; 12 U.S.C. § 1441 et seq

This act reauthorizes and amends the Coastal Barrier Resources Act of 1982 (16 U.S.C 3501-3510). The original act established a policy that coastal barriers, in certain geographic areas of the U.S., and their adjacent inlets, waterways and wetlands resources are to be protected by restricting Federal expenditures which have the effect of encouraging development of coastal barriers. The act provided for a Coastal Barrier Resources System (CBRS) which identified undeveloped coastal barriers along the Atlantic and Gulf Coasts, including islands, spits, and bay barriers that are subject to wind, waves, and tides such as estuaries and nearshore waters (the extent of which is defined by a set of maps approved by Congress dated 30 September 1982). Except for specific exempted projects (e.g. dredging, Federal navigation projects, some habitat management and enhancement efforts), no new Federal expenditures or financial assistance are allowed for areas within the system. The purpose was to minimize loss of human life, wasteful expenditure of federal revenues, and damage to fish, wildlife and other natural resources associated with the development of coastal barriers. The 1990 reauthorization, Coastal Barrier Improvement Act (16 U.S.C. 3501 et seq), provides for the technical revision of maps, modification of boundaries, and additions to the CBRS.

5.1.4 Endangered Species Act (ESA)

UNITED STATES CODE CITATION: 16 U.S.C. 1531 et seq.

The purposes of this Act are to provide a means whereby the ecosystems upon which endangered species and threatened species depend may be conserved and to provide a program for the conservation of such endangered species and threatened species (16 U.S.C. 1531). It establishes a policy that all Federal departments and agencies seek to conserve endangered species and threatened species and utilize their authorities in furtherance of the purposes of this Act (16 U.S.C. 1531 and 1536).

Section 7 (16 U.S.C. 1536) states that all Federal departments and agencies shall, in consultation with and with the assistance of the Secretary of the Interior/Commerce, insure that any actions authorized, funded, or carried out by them do not jeopardize the continued existence of any endangered species or threatened species, or result in the destruction or adverse modification of habitat of such species which is determined by the Secretary (Interior/Commerce) to be critical, unless an exception has been granted by the Endangered Species Committee (16 U.S.C.1536(a)(2)).

Section 9 (16 U.S.C. 1538) identifies prohibited acts related to endangered species, and prohibits all persons, including all Federal, state and local governments, from taking listed species of fish and wildlife, except as specified under the provisions for exemptions (16 U.S.C. 1539). The term "take" is defined as to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, or collect, or to attempt to engage in any such conduct (16 U.S.C. 1532(18)). Provisions for civil penalties, criminal violations, enforcement, and citizen suits are found at 16 U.S.C. 1540. Additional guidelines for protection of marine mammals are established in the Marine Mammal Protection Act of 1972, as amended. Consultation procedures are administered by the Fish and Wildlife Service (USFWS), Department of the Interior, and the National Marine Fisheries Service (NMFS), Department of Commerce.

Federal agencies must request that the USFWS or NMFS, as appropriate, furnish information as to whether any listed species or designated critical habitat are in the proposed project area. If the USFWS/NMFS provides listed or proposed species or designated critical habitat, the lead Federal agency shall prepare a *biological assessment* to determine if the proposed project may affect the species or their habitat. The biological assessment shall be completed within a time period mutually agreed to by the lead Federal agency, the USFWS, and/or the NMFS, and before a project is begun. Areas that should be avoided or critically considered, as well as opportunities for conserving these resources will be considered during formulation of alternative plans.

If a biological assessment indicates that an alternative plan(s) may affect a listed species or critical habitat, the lead Federal agency will request formal consultation with the USFWS/NMFS. If the assessment determines that the alternative plan(s) is not likely to adversely affect the species or critical habitat, then the lead Federal agency may request informal *consultation* with the USFWS/NMFS to receive their written concurrence with the determination of no adverse affect. If the USFWS/NMFS do not concur with the no adverse determination, the USFWS/NMFS may request that the lead Federal agency initiate formal consultation.

The finding, by the lead Federal agency, that a proposed activity will negatively impact an endangered or threatened species, or its critical habitat, will initiate the preparation of a *biological opinion* by the USFWS and/or the NMFS. This biological opinion will include a detailed discussion of the effects of the proposed action on the species or its critical habitat, and a summary of the information upon which the opinion is based. The biological opinion will also include a determination on whether the proposed action is likely to *jeopardize* the continued existence of a listed species or adversely modify its critical habitat. If a jeopardy decision is reached, the resource agencies will suggest *reasonable and prudent alternatives* for the proposed action, if any are possible. The lead Federal agency is required to carefully consider the reasonable and prudent measures to protect and conserve the species and critical habitat. The biological opinion may also include a conservation plan, which the lead Federal agency is not required to implement, but should consider to see of the plan or portions of the plan may be implementable.

An incidental take provision is included in all biological opinions, where an anticipated take may occur, whether there is a "no jeopardy" of "likely jeopardy" opinion. This provision permits the "take" of a specified number of the protected species, or impact a specified acreage of habitat in the project area, without being subject to the penalties established in 16 U.S.C. 1540. The incidental take statement will also specify "reasonable and prudent" measures necessary to minimize impacts; set for terms and conditions; and specify procedures to be used to handle or dispose of any individuals of a species taken.

Consultation shall be concluded within a 90 day period (or other period mutually acceptable to the agency and USFWS/NMFS). During consultation, the lead Federal agency cannot make any irreversible or irretrievable commitment of resources that would have the effect of foreclosing the formulation or implementation of any reasonable and prudent alternative measures.

USFWS/NMFS will provide list of species, within 30 days of request; Biological Assessment completed by the lead Federal agency within 180 days from receiving Species List, or within a time period mutually agreed to by the lead Federal agency and resource agencies, and before construction is begun; Biological Opinion completed by the USFWS/NMFS within 90 days, and 45 days to deliver, a total of 135 days.

5.1.5 Marine Mammal Protection Act

UNITED STATES CODE CITATION: 16 U.S.C. § 1361 et seq, 1401-1407, 1538, 4107

This Act establishes a moratorium on the taking and importation of marine mammals and marine mammal products, with exceptions for scientific research, allowable incidental taking, exemptions for subsistence activities by Alaskan natives and hardship exemptions (16 U.S.C. 1371).

During preparation of the NEPA document, coordination with USFWS and the NMFS will include the discussion of potential impacts to any species covered by this Act. USFWS will provide their comments in the form of a letter or as part of the Fish and Wildlife Coordination Act Report (Fish and Wildlife Coordination Act 16 U.S.C. 662 et seq.). NMFS will provide their comments in a letter. The concerns and/or recommendations of either agency must be addressed. All practicable efforts will be made to avoid taking of a marine mammal. If the taking of a marine mammal is unavoidable, then the responsible agency (USFWS or NMFS) will be contacted to begin the process of obtaining a permit for any take.

It usually takes a minimum of a year to obtain a permit, if no additional studies are necessary. This lengthy time period is necessary because the issuance of a permit must be in the form of a regulation that must appear in the Federal Register and be coordinated with the Marine Mammal Commission, Committee of Scientific Advisors on Marine Mammals, and the public.

5.1.6 Marine Protection, Research and Sanctuaries Act (MPRSA)

UNITED STATES CODE CITATION: 33 U.S.C. § 1401- 1445; 16 U.S.C. § 1431 et seq; also 33 U.S.C. 1271

The Act passed in 1972 regulates the dumping of materials into ocean waters. It prevents, or restricts, dumping of materials that would degrade or endanger human health, welfare, or amenities, or the marine environment, ecological systems, or economic potentialities. The Act provides for a permitting process to control the ocean dumping of dredged material. The Act also establishes the marine sanctuaries program, which designates certain areas of the ocean waters as sanctuaries in order to preserve or restore these areas for their conservation, recreational, ecological, or aesthetic values.

Section 102 (33 U.S.C. 1412) authorizes the Administrator of the Environmental Protection Agency (EPA) to promulgate the ocean dumping criteria, to designate recommended ocean disposal sites, and to issue permits for dumping of materials into ocean waters (except for dredged material, which is regulated by the Corps). Section 103 (33 U.S.C. 1413) authorizes the Secretary of the Army to issue permits for the transportation and disposal of dredged material in ocean waters. The disposal must meet the criteria established by the EPA (40 C.F.R. 227 & 228).

Section 302 (16 U.S.C. 1433) of the Act authorizes the Secretary of Commerce to designate areas as marine sanctuaries for the purpose of preserving or restoring such areas for their conservation, recreational, ecological, or aesthetic values. Title V of the Water Resources Development Act of 1992 (WRDA 92), "National Contaminated Sediment Assessment and Management Act" (33 U.S.C. 1271) establishes a National Contaminated Sediment Assessment and Management program, and amends a number of sections of the MPRSA.

Section 502(a) (33 U.S.C. 1271) establishes a National Contaminated Sediment Task Force to advise the Secretary of Army and EPA Administrator on implementation of Title V; review reports, programs and pollutants selected for criteria; advise and make recommendations on guidelines and prevention and control measures; and review and advise on means and methods to locate long-term disposal sites. Provisions are made for clerical and technical assistance and compensation of non-Federal members, and the Task Force is directed to provide a report to Congress within two years on findings and recommendations.

The Administrator is directed to conduct a comprehensive survey of aquatic sediment quality in the US, including potential sources of pollution, and within 24 months of enactment to report to Congress on findings with recommendations to prevent contamination. The EPA is also directed to conduct a comprehensive and continuing monitoring program to assess aquatic sediment quality. The monitoring program includes location and extent of pollution; methods and protocols for monitoring; system for data management; assessment of trends over time; identify locations of where pollutants may pose threats to specific resources; establish clearinghouse for information; and, provide a report to Congress on findings within two years.

Section 504(a) amends Sections 103 (c) & (e) of the MPRSA of 1972 (33 U.S.C. 1413(c)) to set procedures and time limits for the Administrator to review and concur with conditions, or nonconcur with a proposed permit by the Secretary for sediment disposal. The permit cannot be issued if a "nonconcur" is issued. If a "concur with conditions" determination is made, the permit issued has to include the specific conditions and require compliance.

Section 505 amends Section 106(d) of the MPRSA of 1972 (33 U.S.C. 1416(d)) to define the applicability of state rules and establish an exception for Federal projects.

The Administrator is directed to designate sites or time periods for dumping, and in conjunction with Secretary, to develop a site management plan for each designated site and describe what should be included in plan and periodic review time frames (33 U.S.C. 1412(c)). A deadline of 1 January 1997 was established for development of management plans at all sites. These amendments also establish a basis for selection and time limits on use of "alternative" disposal sites, designated by the Secretary (33 U.S.C. 1413(b)), provide provisions to ensure consistency with site management plans as part of permit conditions, and to set a time limit of 7 years for permits (33 U.S.C. 141(a)(4)), and establish criminal penalties for violation of provisions and authorize seizure and forfeiture of vessels involved in violation (33 U.S.C. 1415(b).

EPA is responsible for issuing permits for the disposal of non-dredged materials in ocean waters. The Corps is responsible for issuing permits for the transportation and disposal of dredged material for disposal in ocean waters. The Corps applies the same testing criteria for the issuance of permits as EPA, and will issue permits in consultation with EPA and with any state having jurisdiction over the disposal site.

5.1.7 Magnuson-Stevens Fishery Conservation and Management Act

UNITED STATES CODE CITATION: 16 U.S.C. § 1801 et seq.

The Magnuson-Stevens Fishery Conservation and Management Act, as amended by the Sustainable Fisheries Act of 1996 (Public Law 104-267), established a new requirement to describe and identify "essential fish habitat" (EFH) in each fishery management plan. EFH is defined as "those waters and substrate necessary to fish for spawning, breeding, feeding, or growth to maturity". *Waters* include aquatic areas and their associated physical, chemical and biological properties. *Substrate* includes sediment underlying the waters. *Necessary* means the habitat required to support a sustainable fishery and the managed species' contribution to a healthy ecosystem. *Spawning, breeding, feeding, or growth to maturity* covers all habitat types utilized by a species throughout its entire life cycle.

Only species managed under a Federal fishery management plan are covered. Within the study area, these include species listed in Table 2-16.

The Magnuson-Stevens Act requires all Federal agencies to consult with the NMFS on all actions, or proposed actions, permitted, funded, or undertaken by the agency, that may adversely affect EFH. Adversely affect means any impact which reduces the quality and/or quantity of EFH. Adverse affects may include direct (e.g., contamination, physical disruption), indirect (e.g., loss of prey), site-specific or habitat-wide impacts, including individual, cumulative or synergistic consequences of actions.

Activities proposed to occur in EFH areas do not automatically require consultation. Consultations are triggered only when the proposed action may adversely affect EFH, and then, only Federal actions require consultation.

In addition to EFH which will be an important consideration for the use of OCS sand resources, the purpose of this Act is to conserve and manage the fishery resources found off the coasts of the U.S., the anadromous species, and Continental Shelf fishery resources of the United States. The Act promotes domestic commercial and recreational fishing under sound conservation management principles, and establishes standards for fishery conservation and management, and directs the Secretary of Commerce to establish advisory guidelines, based on the national standards, to assist the development of fishery management plans (16 U.S.C. 1851). The Act establishes eight Regional Fishery Management Councils, to prepare, monitor and revise fishery management plans, which will achieve and maintain the optimum yield from each fishery (16 U.S.C. 1852). The Secretary of Commerce has review and approval authority for the regional plans (16 U.S.C. 1854). Members of the Councils include the principal state officials with marine fishery management responsibility and expertise, the regional directors of the National Marine Fisheries Service, and individuals appointed by the Secretary of Commerce who are knowledgeable regarding the conservation, management, or the commercial or recreational harvest, of fishery resources of the geographical area. The Councils are to: 1) enable the states, fishing industry, consumer and environmental organizations, and any other interested parties to participate in, and advise on the establishment and administration of such plans; and 2) take into account the social and economic needs of the States (16 U.S.C. 1801). Each Council may comment on or make recommendations concerning any activity undertaken, or proposed to be undertaken, by any state or Federal agency that the Council feels may substantially affect the habitat of a fishery resource that is under its jurisdiction, or the habitat of an anadromous fishery under its jurisdiction (16 U.S.C. 1852).

Within 45 days after receiving a comment or recommendation from a regional Council, a Federal agency will provide a written detailed response to the Council regarding the matter raised and including, in the case of a comment or recommendation concerning any activity the Council views as likely to substantially affect the habitat of an anadromous fishery resource under its jurisdiction, description of the measures being considered by the agency for mitigating or offsetting the impacts of the activity on such habitat (16 U.S.C. 1852).

The Secretary of Commerce develops advisory guidelines, and regulations for implementation of this Act, and evaluates the plans prepared by the Regional Councils. The eight Regional Management Councils prepare and submit fishery management plans, periodic reports to the Secretary of Commerce, and provide comments or recommendations to state or Federal agencies regarding actions that may affect the habitat of resources within their jurisdiction.

5.1.8 Clean Water Act

UNITED STATES CODE CITATION: 33 U.S.C. 1251 et seq.

This Act is the principal law governing pollution control and water quality of the Nation's waterways. The objective of this Act is to restore and maintain the chemical, physical and biological integrity of the Nation's waters (33 U.S.C. 1251). The Act has been amended numerous times and given a number of titles and codification (see footnote below). It was originally enacted as the Water Pollution Control Act in 1948 (P.L. 80-845), and was totally revised by the 1972 amendments, the Federal Water Pollution Control Act Amendments (P.L. 92-500). The 1972 amendments gave the Act its current form, and established a national goal of eliminating all pollutant discharges into U.S. waters by 1985 and an interim goal of making the waters safe for fish, shellfish, wildlife and people by July 1, 1983 (86 Stat. 816, 33 U.S.C. 1251). The 1977 amendments (the Clean Water Act of 1977 (P.L. 95-217)) gave the Act its current title. Additional amendments were enacted in 1981 (Municipal Wastewater Treatment Construction Grants Amendments (P.L. 97-117)) and in 1987 (Water Quality Act of 1987 (P.L. 100-4).

<u>Ocean Discharges</u>. Section 403 of the 1972 amendments (33 U.S.C. 1343) addresses criteria and permits for discharges into the territorial seas, the contiguous zone, and the oceans.

<u>Permits for Dredged or Fill Material</u>. Section 404 (33 U.S.C. 1344) authorizes a separate permit program for the disposal of dredged or fill material in the Nation's waters, to be administered by the Secretary of the Army, acting through the Chief of Engineers. Under Section 404 of the amended Act, the Corps of Engineers retains primary responsibility for permits to discharge dredged or fill material into waters of the United States. The Act also defines the conditions which must be met by Federal projects before they may make discharges into the Nation's waters. Under the program, permits are to be issued, after notice and opportunity for public hearings for disposal of such material at specified sites. Sites are to be selected in compliance with guidelines developed by EPA in conjunction with the Secretary of the Army. EPA is authorized to forbid or restrict the use of specified areas whenever it determines that disposal of material at a specific site would have an unacceptable adverse effect on municipal water supplies, shellfish, and fishery areas, or recreational activities.

> <u>Civil Works Projects</u>. Projects involving the discharge of dredged or fill material into the waters of the United States, must be developed in accordance with guidelines promulgated by the Administrator of the Environmental Protection Agency (EPA) in conjunction with the Secretary of the Army under the authority of Section 404(b)(1) of the CWA (40 C.F.R. 230) unless the activity is exempt under Section 404(f).

Procedures for the evaluation of potential contaminant-related impacts associated with the discharge of dredged material, as required by the Section 404(b) (1) Guidelines are contained in the "Evaluation of Dredged Material Proposed for Discharge in the Waters of the U.S. - Testing Manual " commonly referred to as the Inland Testing Manual which was jointly developed by the EPA and the Corps. The investigations and analysis required by the Section 404(b)(1) Guidelines shall be included in feasibility reports. (ER 1105-2-100)

Dredged Material Testing. Dredged material and sediments beneath the navigable waters proposed for dredging shall be tested and evaluated for their suitability for disposal in accordance with the appropriate guidelines and criteria adopted pursuant to Section 404 of the Clean Water Act and/or Section 103 of the Marine Protection Research and Sanctuaries Act (MPRSA) and supplemented by the Corps of Engineers Management Strategy for Disposal of Dredged Material: Containment Testing and Controls (or its appropriate updated version) as cited in Title 33 C.F.R. Section 336.1.

5.1.9 Clean Air Act

UNITED STATES CODE CITATION: 42 U.S.C. Section 7401 et. seq., Clean Air Act.

OTHER TITLES AND REGULATIONS: 40 CFR 6, 40 CFR 50 - 63, 40 CFR 70 -71, 40 CFR 93.

The Clean Air Act (42 U.S.C. Section 7401 et seq) and 1990 amendments (CAAA) directed the U.S. EPA to establish National Ambient Air Quality Standards (NAAQS, 40 CFR 50) that would provide ambient air concentrations limits of specific criteria pollutants including carbon monoxide, sulfur dioxide, particulate matter, ozone, nitrogen dioxide, and lead to ensure that the basic health and environmental protection are met everywhere in the country.

Any project sites that do not meet these NAAQS are designated as nonattainment areas, and the States have to adopt the implementation plans (SIP or FIP) to further control the air emissions and achieve the standards within a federally approved period (40 CFR 51 - 52, and 62). To be consistent with the enforcement required for the nonattainment states, the EPA developed the conformity rules and air emission thresholds for all federal activities within nonattainment or maintenance areas to conform to the state or federal implementation plans (40 CFR 6, 51, and 93).

Under the Clean Air Act law, the National Emissions Standards for Hazardous Pollutants (NESHAPS) have been established for various source categories (40 CFR 63). The U.S. EPA plans to regulate the emissions of 189 hazardous air pollutants and apply the maximum achievable control technology for these source categories. The NESHAPS concerns of the project would result from the dredging activities, heavy-duty equipment employed, and dredged materials exposed directly to the air which is a relatively slow process, etc.
Beach nourishment/coastal restoration projects would also be subject to the Standards of Performance for New Stationary Sources (40 CFR 60) if any dredging or placement activities involve in the operations of new stationary sources. A project's dredging and beach nourishment activities usually involve in both stationary and mobile sources air emissions, in which the sources that stay in one place are referred to as stationary sources; sources that move around, such as materials transport, are considered mobile sources.

Regional plans for improving air quality in nonattainment areas are typically developed and managed by county or municipal governments, in cooperation with state regulatory agencies. When an air permit is determined to be required by the state, the project will be subject to State and Federal Operating Permit Programs (40 CFR 70 and 71).

5.1.10 Coastal Zone Management Act (CZMA)

UNITED STATES CODE CITATION: 16 U.S.C. § 1451-1464

The CZMA provides for state review of Outer Continental Shelf lease sales, exploration, and development. The Act requires consistency of Federal activities with federally approved coastal zone management plans. All four states in the project area (NJ, DE, MD, and VA) have approved coastal zone management plans. Additional discussion of the state CZM program is provided in Section 5.3.1.

The Act (as amended) establishes a policy: 1) to preserve, protect, develop and where possible, restore and enhance the resources of the Nation's coastal zone for current and future generations; and, 2) to encourage and assist states in their responsibilities in the coastal zone through development and implementation management programs to achieve wise use of the land and water resources of the coastal zone, giving full consideration to ecological, cultural, historic, and esthetic values, as well as the needs for compatible economic development (16 U.S.C. 1452).

Guidelines are set forth to develop a program for the management, beneficial use, protection and development of the land and water resources of the Nation's coastal zones through protection of natural resources, management of development, providing public access, and establishment of pollution control. It delegates responsibility to coastal states to exercise their responsibilities as owners of coastal zone areas to develop and implement management programs to achieve wise use of the land and water resources. Participation and cooperation is encouraged among state and local governments, interstate regional agencies and Federal agencies to help states manage competing demands in coastal areas. The Secretary of Commerce is authorized to award Federal grants to assist the states in developing and administering management programs, land and water use for the coastal zone giving full consideration to ecological, cultural, historic and esthetic values as well as to the need for economic development.

The 1980 amendments provided for the development of special area management plans (SAMPs) for areas of the coastal zone considered to be of particular importance. SAMPs are comprehensive plans that provide for natural resource protection and reasonable coastal-dependent economic growth containing a detailed and comprehensive statement of policies; standards and criteria to guide public and private uses of lands and waters; and mechanisms for timely implementation of the designated geographic areas (16 U.S.C. 1453(17)). They are also intended to provide for increased specificity in improved protection of life and property in hazardous areas, including those areas likely to be affected by land subsidence, sea level rise, or fluctuating water levels of the Great Lakes, and improved predictability in governmental decision making (16 USC 1452(3).

Section 307 (16 U.S.C. 1456(c)(1)(A)) directs Federal agencies proposing activities or development projects including Civil Works activities, whether within or outside of the coastal zone, that are reasonably likely to affect any land or water use or natural resource of the coastal zone, to assure that those activities or projects are consistent, to the maximum extent practicable, with the approved state programs. Non-Federal projects requiring a Federal permit for an activity in or outside of the coastal zone, affecting any land or water use or natural resource of the coastal zone of the state, must provide certification to the permitting agency that the proposed activities comply with the enforceable policies of the states approved program.

No license or permit shall be granted by a Federal agency until the state has concurred with the applicant’s certification or until the state has waived its right to do so (16 U.S.C. 1456 (c)(3)(A)).

The Coastal Zone Act Reauthorization Amendments (CZARA) of 1990 authorized NOAA to undertake a Coastal Nonpoint Pollution Control Program. State and local authorities are to develop and implement management measures for nonpoint source pollution to restore and protect coastal waters (16 U.S.C. 1455(b)).

5.1.11 National Historic Preservation Act (NHPA)

UNITED STATES CODE CITATION: 16 U.S.C. § 470 et seq

The Act establishes preservation as a national policy and directs the Federal government to provide leadership in preserving, restoring and maintaining the historic and cultural environment of the Nation. Preservation is defined as the protection, rehabilitation, restoration, and reconstruction of districts, sites, buildings, structures, and objects significant in American history, architecture, archeology, or engineering. The Act authorizes the Secretary of the Interior to expand and maintain a national register of districts, sites, buildings, structures, and objects significant in American history, architecture, archaeology and culture, referred to as the National Register.

The 1980 amendments established guidelines for nationally significant properties, curation of artifacts, and data documentation of historic properties, and preservation of Federally owned historic sites; required designation of a Preservation Officer in each Federal Agency; authorized the inclusion of historic preservation costs in project planning costs; and, authorized the withholding of sensitive data on historic properties when necessary. Federal agencies are directed to maintain historic properties in ways that consider the preservation of historic, archeological, architectural, and cultural values. Federal historic preservation programs shall insure that the preservation of properties not under the jurisdiction or control of agencies, but subject to be potentially affected by agency actions, are given full consideration in planning.

Federal agencies having direct or indirect jurisdiction over a proposed Federal or federally assisted undertaking shall take into account the effect of the undertaking on any district, site, building, structure, or object that is included in or eligible for inclusion in the National Register. Federal agencies shall afford the Advisory Council on Historic Preservation a reasonable opportunity to comment on each undertaking (Section 106 (16 U.S.C. 470f). In addition, federal agencies shall assume responsibility for the preservation of historic properties that are owned or controlled by the agencies. They also shall establish a program to locate, inventory and nominate all properties under the agency's ownership or control that are eligible for inclusion on the National Register (Section 110(16 U.S.C. 470h-2)).

The MMS must be able to document compliance with the Act by including relevant coordination or consultation correspondence, study results, agency views and comments, and, if required, mitigation plans in MMS project reports and NEPA documents. The Act requires Federal agencies to develop and implement professional qualification standards for Federal employees and contractors.

Section 106, Review Process, directs Federal agencies, with direct or indirect jurisdiction over proposed Federal or Federally assisted undertakings, to take into account effects on historic properties, in accordance with regulations issued by the Advisory Council on Historic Preservation, and in consultation with the Council and the State Historic Preservation Officer.

Section 110 requires Federal agencies to assume responsibility for the preservation of historic properties owned or controlled by them and requires them to locate, inventory, and nominate all properties that qualify for the National Register. Agencies shall exercise caution to assure that significant properties are not inadvertently transferred, sold, demolished, substantially altered, or allowed to deteriorate.

5.2 Executive Orders

5.2.1 E.O. 11514 Protection and Enhancement of Environmental Quality

Directs Federal agencies to initiate measures needed to direct their policies, plans, and programs to meet national environmental goals. Federal agencies are responsible for developing procedures (e.g., public hearings, information on alternative courses of action) to ensure the public can review, understand, and comment on Federal plans and programs with environmental impacts in a timely manner.

The Council on Environmental Quality (CEQ) developed regulations requiring EISs to be more concise, clear, and to the point, (and therefore more useful to the decisionmakers) in response to this executive order.

5.2.2 E.O. 11990 Protection of Wetlands

This order directs all Federal agencies to avoid, if possible, adverse impacts to wetlands and to preserve and enhance the natural and beneficial values of wetlands. Each agency shall avoid undertaking or assisting in wetland construction projects unless the head of the agency determines that there is no practicable alternative to such construction and that the proposed action includes measures to minimize harm.

Also, agencies shall provide opportunity for early public review of proposals for construction in wetlands, including those projects not requiring an EIS.

5.2.3 E.O. 12898 Environmental Justice

Federal agencies shall make achieving environmental justice part of their missions by identifying and addressing, as appropriate, disproportionately high and adverse human health or environmental effects of its programs, policies, and activities on minority populations and low-income populations.

5.3 State Regulations

5.3.1 Coastal Zone Management

In general, the state management programs provide for: (A) the protection of natural resources, including wetlands, flood plains, estuaries, beaches, dunes, barrier islands, coral reefs, and fish and wildlife and their habitat, within the coastal zone; (B) the management of coastal development to minimize the loss of life and property caused by improper development in flood-prone, storm surge, geological hazard, and erosion-prone areas and in areas likely to be affected by or vulnerable to sea level rise, land subsidence, and saltwater intrusion, and by the destruction of natural protective features such as beaches, dunes, wetlands, and barrier islands; (C) the management of coastal development to improve, safeguard, and restore the quality of coastal waters, and to protect natural resources and existing uses of those waters; (D) priority consideration to coastal-dependent uses and orderly processes for siting major facilities related to national defense, energy, fisheries development, recreation, ports and transportation, and the location, to the maximum extent practicable, of new commercial and industrial developments in or adjacent to areas where such development already exists; (E) public access to the coasts for recreation purposes; (F) assistance in the redevelopment of deteriorating urban waterfronts and ports, and sensitive preservation and restoration of historic, cultural, and esthetic coastal features; (G) the coordination and simplification of procedures in order to ensure expedited governmental decision making for the management of coastal resources; (H) continued consultation and coordination with, and the giving of adequate consideration to the views of, affected Federal agencies; (I) the giving of timely and effective notification of, and opportunities for public and local government participation in, coastal management decision making; (J) assistance to support comprehensive planning, conservation, and management for living marine resources, including planning for the siting of pollution control and aquaculture facilities within the coastal zone, and improved coordination between State and Federal coastal zone management agencies and State and wildlife agencies; and, (K) the study and development, where appropriate, of plans for addressing the adverse effects upon the coastal zone of land subsidence and of sea level rise (16 USC 1452 (2)).

If a state has an approved coastal zone management program through the Office of Coastal Zone Management (NOAA) (as is the case with the four states in the project area), Federal agencies with development projects within the coastal zone, including Civil Work activities, must assure that those activities or projects are consistent to the maximum extent practicable, with the approved state program. Non-Federal applicants proposing activities affecting land or water uses in the coastal zone are required to furnish certification that the activity is in compliance with the approved state coastal zone management plan. Generally, no permit will be issued until the state has concurred with the non-Federal applicant's certification, unless the State has waived its right to do so.

5.3.2 Water Quality Certification

Section 401 of the CWA requires that certification be obtained from the State or interstate water control agencies that a proposed water resources project is in compliance with established effluent limitations and water quality standards. If the State in question has assumed responsibilities for the 404 regulatory program, a State 404 permit would be obtained which would serve as the certification of compliance. Section 404(r) waives the requirement to obtain the State Water Quality certificate if the information on the effects of the discharge are included in an EIS on the proposed project submitted to Congress before the discharge takes place and prior to either authorization of the project or appropriation of construction funds. It is the general policy of the Corps to seek State water quality certification rather than utilizing the Section 404(r) exemption (ER 1105-2-100). Applicants for Corps permits must obtain certification from the State for activities involving discharges.

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7.0 GLOSSARY

Active draghead – draghead in the operation of dislodging material from the sea floor.

Aggregate – a mass or body of rock particles, mineral grains or a mixture of both. May contain sveeral hard, inert materials, such as sand, gravel, slag or crushed stone.

Ambient air – that portion of the atmosphere to which the general public has access.

Anadramous – pertaining to fishes, such as herrings, shad, and striped bass, that ascend from their primary habitats in the ocean and spawn in fresh water.

Arcuate – curved or arc-shaped.

Attainment areas – areas that meet National Ambient Air Quality Standards (NAAQS).

Bedform – any deviation from a flat bed.

Benthic plume – sediment suspension created from the rotation of the cutterhead during dredge operations.

Benthos – that area occurring near or at the bottom of a body of water.

Biogenic roughness – the effect of organic rock produced by the physiological activities of organisms, plant or animal, such as coral reefs, shelly limestone, etc., on current velocity.

BOD loadings – (Biological Oxygen Demand) – organic matter which results in an oxygen demand in an aquatic system.

Catadromous –fish that descend from their primary habitat in fresh water to spawn in the open ocean.

Cold core rings/eddies – eddies detached from the Gulf Stream by sheer-flow processes in which local, cold water is enclosed by warmer water. They are also referred to as cyclonic (counterclockwise flow) eddies and exhibit large vertical structure and may extend several kilometers deep. They are characterized bya "doming" toward the surface of deep isotherms. Non-linear flow within the structure may persist for months.

Cutterhead – a rotating cutter composed of plain or toothed blades enclosing a suction pipe and used to excavate all types of compacted sediments.

Cutter suction dredge – a hydraulic suction dredge that employs a rotating cutting apparatus to dislodge compacted soils and rock.

Davit – an inverted L-shaped support structure that hangs over a ship side, used to support heavy loads by means of cables and winches. On a trailer suction dredge, the trailer pipe is supported, raised and lowered on a davit.

Demersal – pertaining to fish (groundfish) that live near the bottom of the ocean; may also refer to eggs that are denser than water and sink to the bottom after spawning.

Detached ridges – Ridges with closed contours, not attached to shore.

Draghead – a device that fits on the end of a trailer suction pipe and makes contact with material being dredged. They are designed to dislodge the material from the sea bed and to convey the dislodged sediment towards the entrance of the suction pipe.

Economic Exclusion Zone – a zone of marine waters extending from the U.S. territorial sea to 200 nautical miles off shore (*i.e.*, federal waters).

Environmental window – refers to temporal periods when dredging may have minimal adverse impact on the environment. An example is the timing of dredging to avoid periods when fish are migrating or spawning in a given area.

Epifauna – animals living on or just above any substratum.

Essential Fish Habitat – those waters and substrate, as authorized by the Magnuson-Stevens Act, necessary to fish for spawning, breeding, feeding, or growth to maturity.

Extratropical storm – storms that originate in the middle-latitude westerly wind belt (*i.e.*, outside tropical waters). Nor'easters fall within this class of storm.

Fathom – a measure of depth equivalent to 6 feet.

Firing fan – nearshore areas containing various ordnance from training or firing activities that extend offshore and create a fan-like pattern.

Gravel – the coarsest of alluvial sediments, containing mostly particles larger than 2 mm and including cobbles and boulders.

Head boat – also known as party boat; vessel chartered for a large number of anglers for recreational fishing.

Heave compensation – the process of reducing the effects of induced motion of a trailer suction dredge on the trailing pipe and draghead, in order to maintain a constant contact with the sea bed while dredging in rough seas.

High beach zone – area between high tide mark left by the previous high tide and the primary dune.

Hypothetical resources – resources that could occur on trend with or close to identified resource deposits (MMS 1994).

Identified resources – deposits whose locations and characteristics are known or estimated from geologic data within or close to the deposits (MMS 1994).

Indicated resources – based on data similar to those used for measured resources, with sampling sites farther apart, but close enough to show deposit continuity.

Indicator species – species that indicates the type of habitat or environmental conditions of the area it inhabits. A prevalent species of a specific area.

Inferred resources – resources for which there is some geologic evidence, based on assumed continuity beyond deposits of measured and/or indicated resources (MMS, 1994).

Isopycnal – lines of equal density.

Ladder – a support structure of the cutter suction dredge that contains the suction pipe and cutterhead. The ladder is attached to the hull of the dredge by hinges which permit rotation in the vertical plane. The ladder is raised and lowered by means of a hoisting winch.

Launders – chutes in hopper dredges designed to minimize turbulence during loading.

Leptocephali – leaf-shaped larval stage of some eels.

Littoral zone – the depth zone between the high water and low water mark.

Longshore transport – the transport of materials parallel to the beach, caused by wave action.

Macroinvertebrate – invertebrates visible to the naked eye.

Marine snow – fiocculation and aggregation of suspended matter into larger particles.

Measured resource – deposits whose character is well-established by a closely-spaced grid of sampling sites and geophysical data (MMS, 1994).

Meristic – having a number of parts, or divided into serially repeated, countable features (*e.g.*, the rays in a fin, the myomeres of an eel larva, the rakers on a gill arch, etc.).

Mud – material finer than sand and lubricated with water.

Neuston – organisms that inhabit the surface water and air interface of the ocean.

Nonattainment areas – areas that do not meet National Ambient Air Quality Standards (NAAQS).

Nonterrigenous sediment – sediment not derived from the land.

Nor'easter (or northeaster) – storm systems that are typically associated with cyclonic (or low-pressure) disturbances that originate in the middle-latitude westerly wind belt and generate strong northeasterly winds and damaging waves along the shoreline.

Omnivorous – organism that consumes both plant and animal.

Pelagic – pertaining to organisms that are "free swimming" and inhabit open ocean waters.

Phi grade scale – a logarithmic transformation of the Wentworth grade scale in which the negative logarithm to the base 2 of the particle diameter (mm) is substituted.

Placer deposit – a detrital sedimentary deposit of a valuable mineral or native metal in unusually high concentration, segregated by its greater density.

Planktivorous – organisms which consume plankton.
Primary production – organic matter produced by autotrophs or organisms that synthesize high-energy organic

compounds from inorganic compounds.

Punaise method – a method of hydraulic dredging that employs a remotely operated submersible pump. The word "Punaise" is Dutch for thumbtack and refers to the general shape of the device.

Pycnocline – the region within the water column in which a density gradient or change is evident.

Rainbow method – a sand placenment technique that utilizes a hopper dredge pumping its cargo of sand directly onto the beach with a powerful hydraulic pump. This method has limited application to beach nourishment as it requires special site conditions such as steep slopes along the foreshore and calm sea conditions.

Ravinement surface – surface created by the irregular junction marking a break in sedimentation caused by the formation of a ravine.

Sand – rounded rock or mineral grains with diameters between .074 mm and 4.76 mm.

Sand ridge – a generic name given to any low ridge of sand formed at some distance from the shore, either submerged or emergent.

Secondary production – production of herbivorous animals.

Seismic – pertaining to an earthquake or earth vibration, including those that are artificially induced.

Shelf water – coastal water subject to large seasonal variations, i.e., river runoff and air-sea interactions.

Shoal – a submerged ridge, bank or bar consisting of or covered by sand, rising from the substrate of a body of water.

Shoal retreat massif – a broad shelf-transverse sand ridge that marks the retreat of a zone of littoral drift.

Significant wave height – the average of the highest one-third of the waves in a data set.

Silt – a rock fragment or detrital particle smaller than a very fine sand grain with diameter of the range from 1/256 to 1/16 mm.

Skewness – a measure of asymmetry of a frequency distribution.

Slope gyre – an elongated cyclonic movement of slope water generated by the stress of the Northward flowing Gulfstream and coastal water.

Slope water – water overlying the continental shelf, defined by the mixing of shelf water and open ocean masses.

Slurry – a fluidized mass of dredged material that is sent through a pipeline deployed on the seabed, for discharge to the beach.

Sorting – a measure of the range of the particle size distribution on either side of an average.

Speculative resources – resources that might occur in areas where sand and gravel were thought not to exist

(MMS 1994).

Stepping spud – refers to the spud on a dredge that is in a raised position, allowing the dredge to rotate about the opposite or “working spud”.

Stock level – a measure of stock status: stock is a biologically distinct and interbreeding species within a population of aquatic animals.

Supralittoral zone – pertaining to the shore area marginal to the littoral zone, just above high tide level.

Surface plume – suspended sediments generated by the overspill of dredge hoppers that may extend up to 20 km on the surface of the ocean.

Swash zone – the area offshore where there is a landward rush of water created from breaking waves as they move up the slope of the beach.

Sympatric – co-existing in the same area or region.

T-S structure – temperature/salinity structure.

Target species – species that are targeted for capture.

Terrigenous sediment – sediment derived from the land or from a continent.

Teuthivores – species that feed upon fish and squid.

Thalweg – a sinuous imaginary line following the deepest part of a stream.

Trace metals – metals present within the substrate in relatively small concentrations (e.g., barium, cadmium, iron, lead, nickel, etc.)

Trailer suction dredge – a ship that can dredge while underway by trailing a hydraulic suction pipe along the sea bed and conveying the dredged material to an onboard hopper.

Turbidity plume – a benthic or surface plume created by dredging operations in which sediment is suspended within the water column.

Undiscovered resources – resources whose existence is postulated from indirect geologic evidence, such as trends in seafloor morphology (MMS, 1994).

Vibracore – a cored sample extracted from underwater unconsolidated sediments with a vibrating drill pipe.

Warm core rings/eddies – eddies detached from the Gulf Stream by sheer-flow processes in which warm Gulf Stream water is surrounded by colder, local water. They are also referred to as anticyclonic (clockwise flow) eddies and exhibit large vertical structure. They result in a deepening of local isotherms.

Wave period – the time interval between successive crests of waves passing a given point.

Winnowing – the natural process of removing very fine-grained sand or silt from a recent sand placement by wave and current action.

Working spud – the spud of a dredge that is embedded into the sea bed, “spudded in.” This spud holds the dredge in place while at the same time allows rotation about the spud.

Young-of-year – juvenile stage of organism for a particular year.

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Appendix A. Potential Environmental Impacts of Offshore Aggregate Mining

1.0 Introduction

Aggregate material refers to sand, gravel, and crushed stone which is used primarily in public works projects such as roads, highways, and airports, and private industrial, commercial, and residential construction. Aggregate material is generally available throughout the United States. Sand and gravel are produced commercially in every state in the U.S., and crushed stone is produced in every state except Delaware (USGS 1993). Aggregate production accounts for approximately half of the nonfuel-mining volume in the U.S. In 1996, as reported by the USGS, 914,000,000 metric tons of sand and gravel were produced in the US. The estimate of production for 1998 is in excess of 1 billion metric tons with a total dollar value of approximately $4.3 billion annually. As a result, it is a major component of the minerals producing industry. Because sand and gravel is a low value commodity, but one that is used in practically every major construction project, they are produced in almost every county in the United States by thousands of individual operators. Because of the bulky nature of sand and gravel, there is little interstate movement with prices for sand and gravel heavily dependent upon transportation costs. Table A-1 shows the 1998 production estimates for the Mid-Atlantic states.

Table A-1: Estimated Production of Sand and Gravel for the Mid-Atlantic Region, 1998. (Based on preliminary data from the USGS, 1999).

State	Metric Tons x 10^6	Short Tons x 10^6	Equivalent cubic yds. x 10^6
New York	32.1	35.3	26.2
New Jersey	18.1	19.9	14.7
Delaware	2.2	2.4	1.8
Maryland	11.7	12.85	9.5
Virginia	10.6	11.65	8.6

1.1 Aggregate Specifications

Physical properties of sands and gravels are obtained mainly from their method of formation and deposition. It is the physical properties and chemical composition that determine the commercial value of deposits and influence the manner of their extraction. High quality sands and gravels are required for the construction industry in order to meet strict construction standards. Although sand and gravels are crude products, the material for aggregate must meet very precise standards with respect to grading, content and shape. Most construction standards are promulgated by the American Society of Testing Materials (ASTM) which lists 179 standards with reference to aggregate content and testing standards. In addition, the USACE has aggregate specifications and almost every state's highway/transportation department has specifications for highway construction. Most of the coastal plain on the Atlantic and Gulf Coasts of the U.S. and offshore waters contains sands, but most of it will not meet aggregate standards as found in their natural state. Aggregate sand is a coarser sand product than the native sand found along the beaches of the Mid-Atlantic region. The median range of grain sizes for beaches in New Jersey and Delaware, for instance, ranges from 0.28 mm to 0.47 mm while the median range for structural grade aggregate sand ranges from 0.45 mm to 1.2 mm. Tables A-2 and A-3 provide examples of grain size standards for concrete grade and masonry sand grade aggregates.

Table A-2: ASTM Standard Specifications for Concrete Aggregates (Fine Aggregate), ASTM C-33, 1997

Sieve Size	Percent Passing
9.5 mm (3/8 in.)	100
4.75 mm (No. 4)	95 – 100
2.36 mm (No. 8)	80 – 100
1.18 mm (No. 16)	50 – 85
0.60 mm (No. 30)	25 – 50
0.30 mm (No. 50)	10 – 30
0.15 mm (No. 100)	2 – 10

Table A-3: ASTM Standard Specifications for Aggregate for Masonry Mortar, ASTM C-144, 1997

Sieve Size	Percent Passing*
4.75 mm (No. 4)	100
2.36 mm (No. 8)	95 – 100
1.18 mm (No. 16)	70 – 100
0.60 mm (No. 30)	40 – 75
0.30 mm (No. 50)	10 – 35
0.15 mm (No. 100)	2 – 15
0.075 mm (No. 200)	0 – 5

* The above grading standards apply to natural sand, slightly different standards apply to manufactured sands.

1.2 Aggregate Sources

There are three sources of aggregate material:

- land-based sources,
- nearshore navigation dredging projects, and
- mining in marine areas.

Within the Mid-Atlantic region, aggregate sources are primarily land-based. Land-based extractions have significant potential impacts on the natural environment due to the alteration of the terrestrial landscape and ecology and may affect air and water quality through emissions during extraction and transport. There are also impacts associated with noise, dust, and visual impacts on the landscape. In addition, zoning and competing land uses may restrict or preclude aggregate mining in areas. In addition, there are associated transportation impacts and costs if aggregates have to be transported long distances.

A private supplier in the New York/New Jersey Metropolitan region is currently mining sands from a federal navigation channel for aggregate purposes. Since 1985, working under a USACE, NY District maintenance dredging permit, the company has been engaged in mining the Ambrose Channel in the Lower Bay between the Verrazano Narrows and the entrance to the harbor. Because of the decreasing coarse sand fraction (see previous section) in the areas being dredged, the company began blending in crushed stone from rock quarries in Morris, Passaic and Somerset counties, New Jersey, in order to meet customers'

specification. Current production of sands and gravels from the Ambrose Channel is 2.0 – 2.5 million short tons (1.5 – 1.9 million cubic yards).

At present, there are no aggregate mining operations conducted in the Federal offshore waters of the U.S. This is in contrast to such countries as Japan and the United Kingdom which obtain a significant quantity of their aggregate supplies from marine sources (Coastline Surveys Limited 1999). In Japan, approximately 85% of all aggregates are from marine sources. Marine dredged aggregate supplies approximately 18% of England and Wales' total aggregate demand, rising on a regional basis to greater than 30% of total demand for southeast England (Coastline Surveys Limited 1999).

In the New York metropolitan area, there are a limited number of land extraction operations and these sources are diminishing. As a result, offshore sources, especially in the northern portion of the project study area, will begin to become more attractive potential sources in the future.

2.0 Potential Offshore Aggregate Source Areas

Primarily as a result of adequate land-based aggregate sources, resource information on commercial reserves of aggregates throughout the project area is sparse. To evaluate a deposit for commercial use, the specifications of the material needed for sale in a specific market would need to be known (MMS 1993). In addition, it is necessary to determine that sufficient tonnage of saleable material exists within the deposit to sustain a profitable operation (MMS 1993). In addition to the areal extent of a potential deposit, parameters such as potential volume, grain size, quality of the deposit, and the percentage and location of unsaleable material within the deposit are important.

The current needs and growth of the offshore sand and gravel industry for aggregate purposes is entirely dependent upon market forces. For economic reasons, potential offshore mining areas and onshore processing plants will be located close to the largest users which will be the metropolitan areas. At the present time, the only market in the Mid-Atlantic region that can support an offshore aggregate industry is the New York/New Jersey area. Table A-1 shows that the combined production for New York/New Jersey is twice that of combined production of the other Mid-Atlantic States, Delaware, Maryland, and Virginia. Most of the other major metropolitan areas in the four-state region (Philadelphia, Baltimore, Washington and Norfolk) are close to terrestrial sources of sand and gravel that can supply their current needs as well as their future needs for some time to come. The situation in the New York Metropolitan Area is different where the combination of a large market and vanishing land-based resources combine to make an offshore aggregate industry potentially viable.

Northern New Jersey Region

The sands and gravels that will be exploited for the New York/New Jersey market are contained in the New York Bight region and offshore of northern New Jersey. It is highly likely that the areas to be exploited for the immediate future will be confined to an area north of 39° 30' latitude and extend offshore no more than 40 – 50 miles (Figure 1-1).

In Section 2.2.2.4 of the main report, the sediment characteristics of the inner continental shelf off New Jersey were discussed. It was shown that gravelly sands (10 to 49% gravel) extend offshore from the federal limit as far as 40 miles in the Beach Haven Inlet to Asbury Park Region and that an area off Island Beach State Park contains coarse sands with over 50% gravel content (Figure 2-23).

3.0 Aggregate Mining Operations

Trailer suction hopper dredges are typically used in aggregate mining operations conducted overseas (Coastline Surveys Limited 1998). Trailer suction hopper dredges are self-propelled ships suitable for operations in an ocean environment and capable of loading a self-contained hopper while the ship is underway. Most trailer suction hopper dredges are twin screw and have bow thrusters which provide a high degree of maneuverability. For dredging in water deeper than approximately 32 m, the dredge pump may be mounted on the dredge pipe, rather than the hull of the dredger (Coastline Surveys Limited 1998). Loading takes place as the ship moves ahead at a speed of 2-3 knots (<4m/s). Offloading is typically by mechanical means (scraper buckets, grabs, or bucket wheels).

The main advantages of the trailer suction hopper dredge are:

- Performing in high sea state conditions with the use of heave compensating drag arms
- Operating independently without tender vessels
- The ability to transport materials over long distance
- The high rate of production
- Operating in relatively deep water

The trailer suction hopper dredge is normally rated according to its maximum hopper capacity, typically in the range of 1,000 cu yds. to 20,000 cu yds. The world's largest trailer suction hopper dredge, "Queen of the Netherlands," commissioned in 1998, has a hopper capacity of 30,350 cu yds.

While most trailing suction hopper dredges are self-propelled ships, some dredges are tug-integrated barges. The propulsion for the barge being supplied by tugs that fit in to notches at the stern of the barge. Figures A-1 and A-2 depict the trailer suction dredges *Long Island* and *Sandy Hook*, respectively, which are used for various dredging projects in the northern portion of the project area. The *Long Island* is the largest dredge of its type operating in the U.S. This dredge has a hopper capacity of 16,000 cu yds and is propelled by a tug of 5,450 hp. The dredge *Sandy Hook* has a hopper capacity of 5,100 cu yds. Both dredges are equipped with single drag arms with a submersible dredge pump mounted in the drag arm and fitted with California type dragheads.

Figure A-1. The trailer-suction dredge *Long Island.*

Figure A-2. The trailer suction dredge *Sandy Hook*.

A large proportion of the internal space of the trailer suction hopper dredge is hopper space into which the material is loaded by one or two large centrifugal pumps. The pumps are usually inboard but may not be fitted into the trailing suction pipe (submerged pump). Submerged pumps are a necessity for all deep water dredges. The suction pipe is stowed inboard when the ship is in transit between the dredging site and the discharge or off loading site.

Maximum Operating Depth

The maximum operating depth to which a hydraulic dredge can operate is limited by the vacuum head generated by the dredge pump. If the pump is mounted within the hull of the vessel, the maximum economical dredging depth is about 100 feet. By mounting the dredge pump externally in the trailing suction pipe, close to the draghead, a much greater depth may be achieved along with improved production. Dredging production from 400 feet deep is now achievable economically. Figure 3-5 shows the relationship of dredging depth to pump power for TSH dredges.

Dredging Procedures

The trailer suction pipe with draghead attached is swung outboard and lowered by means of winches and davits. If inboard pumps are installed, the inboard end of the suction pipe is lowered in a fixed track to mate, below the waterline, with the pump suction intake which is open in the side of the hull. Pipe works from the discharge side are routed to the hopper where discharge is conveyed to launders (chutes) to minimize turbulence. If the dredging pumps are located within the trailing suction pipe then there is a fixed connection of suction and pressure pipe systems.

The intake end of the suction pipe is fitted with a draghead, the function of which is to strip off a layer of sediment from the seabed and entrain those sediments into the suction pipe. The draghead is lowered while the vessel proceeds forward at a speed from 1 to 5 knots. Examples of various dragheads are shown in Figure ---

and in Table – of the main report. The bearing pressure of the draghead on the seabed is controlled by an adjustable pressure compensatory system which acts between the draghead and the hoisting winch which supports the trailing pipe. This same system acts as a heave compensator that accumulates and smoothes out the vertical forces resulting from induced wave motions of the dredge. Because of this heave compensation, the trailer suction hopper can dredge effectively in sea states much higher than those which would limit the effectiveness of a cutter suction dredge.

In soft sediments, the entrapment of soils from the seabed into the suction pipe is produced mainly by the erosive action of the fluid flow produced by the suction action. In denser material, dislodgement of the seabed material is assisted by the rotating action of the scrapers and knife edges of the dragheads. For very firm material, dislodgement may be assisted by the use of high pressure water jets.

The trailer suction pipes are usually articulated along part of their length by means of an articulated link which supports a hose connection between adjoining lengths of rigid pipe. This articulation permits relative movement between the draghead and the vessel. As the vessel pumping continues, the soil particles settle in the hoppers and the excess water passes overboard through overflow troughs. The volume ratio of solids to water is generally around 15% -20%. To reduce surface turbulence, overflow water is conducted along weirs and conveyed along the sides of the dredges opposite to where the dredged material is discharged into the hopper. In addition, to help reduce the effect of a surface plume the overflow is conveyed down along the side of the vessel hull to discharge below the waterline. This allows sufficient time for the particles to settle before overflowing.

Loading Time

The loading times of TSH dredges are highly variable and are dependant upon the physical characteristics of the material being dredged, the mechanical properties and efficiency of the dredging plant and vessel, and the sea state conditions under which the dredging takes place. With coarse material that has a fast settling rate, long overflow times will be required to fill the hoppers to capacity. These times diminish as the particle size becomes smaller because a greater proportion of the solids remain in suspension, causing the density of overflow mixture to be very nearly the same as the density of the mixture being delivered to the hopper. Loading times for very fine dredge material, such as silt and clays, can be very fast, approaching the function of the pumping flow rate and the hopper capacity. Thus, in some cases, the loading time may be as short as 20 minutes of dredging. However, in coarse grained sands and gravels, the dredging rates are much slower, overflow discharges are relatively clean and dredging can take up to 1–2 hours to reach hopper capacity.

Limiting Environmental Factors for Trailer Suction Hopper Dredges

The limitations affecting when and where trailers can operate will vary according to the size and characteristics of the particular dredger, but an indication of the extreme limits which will apply to economic operation is given below. These limits apply respectively to the smallest (minimum) and largest (maximum) of this type of dredger in common use.

Minimum water depth to operate	15 feet
Maximum water depth to operate	150 feet (very few to 300 feet)
Maximum sailing speed	17 knots
Minimum turning circle	250 feet
Maximum wave height	15 feet
Maximum cross current	3 knots
Maximum particle size	300 millimeters

For the aggregate industry, hoppers are offloaded typically by mechanical means with grabs, scrapers or dragline buckets to conveyor lines (Figure A-3).

Figure A-3. Typical offloading operation of aggregate material.

Dredging Technique

Dredging is conducted along prescribed tracklines backward and forward across a designated borrow area. Precise positioning of the dredge (to within submeter accuracy) is maintained by DGPS positioning methods and associated computer software programs. The dredging equipment consists of a long suction pipe with a draghead attached. A dredge may have either one or two suction pipe dragheads. The "Sandy Hook" for instance has a single 27-inch suction pipe and draghead mounted on the port side. Suction is obtained with an underwater centrifugal pump of 1,500 HP (1,120 kW) mounted on the drag arm. The dredging depth of this unit is 85 feet as measured from the water surface. Existing technology allows for dredging at greater depths, however practical limitations preclude sand mining for aggregate beyond the 100 foot depth limit.

Dredging Rate

Typically the draghead will excavate a furrow 2.7 m (8.9 feet) wide. It is estimated that the depth of cut is about 0.15 meter (6 inches). At a forward speed of 2.5 knots approximately 2320 cu yds/hr of solids would be raised from the seabed. The total volume of water and solids will vary between 5 and 7 times the solids volume with the water being discharged back to the sea. The effluent discharge will contain very fine particles which are generally smaller than the –200 mesh (0.074 mm). The amount of these fines will of course depend upon the size composition of the in-situ sand /gravel deposit. The average load for the Dredge "Sandy Hook" for instance is about 4,000 cu yds and the loading time is 1-2 hours depending on sea conditions and the number of turns required in the dredging pattern.

Onshore Processing

To minimize handling and transportation costs, onshore processing plants would be located on the waterfront where material from hopper barges would be offloaded in the most efficient and cost effective manner. In addition, they would be located near intermodal facilities such as railroads and highways for efficient transport of the material to users. Siting of new aggregate facilities would require numerous regulatory approvals including; consistency with the state's coastal zone management program/policies, water quality permits (NPDES, Section 401), Section 404 (Clean Water Act) permits, Section 10 permit, and air quality permits. In addition, site-specific issues with regard to potential impacts to traffic, archaeological/cultural resources, threatened/endangered species, aesthetics, and noise would need to be addressed.

The dredged aggregate material would be offloaded in two ways. One method would use a dry unloading system consisting of scrapper buckets which would collect the material from the barge, place it on conveyor belts which would carry it to open stockpile areas. A second method would pump the material from the hopper barge to a contained holding pit where the sand and gravel is allowed to dewater before being conveyed to the stockpile.

A typical facility for processing dredged sand and gravel consists of the stockpiled raw material being loaded into a feed hopper that feeds a constant volume of raw material to the processing line. The following scheme shows a typical arrangement for processing concrete sand, masonry sand and three size ranges of gravel.

Typical steps in aggregate processing are as follows:

- Raw material is washed and wet screened with brackish water. A triple deck screen separates gravel into three size ranges - >1 $^{1}/_{8}$", ½" – 1 $^{1}/_{8}$", and ¼" – ½".
- The sand fraction (<1/4") is then conveyed to a classifier tank for size separation. The classifier tank called a "Dial Spit" consists of a 48' x 12' tank with 33 slots which can be programmed to extract sand particles as a function of size. The coarse fractions settling into the slots at the front of the tank while the finer particles are carried to the end of the tank.
- Both the concrete sand and the masonry sand are further washed in fresh water to remove additional fine particles that cling to the sand grains and for removal of chlorides.
- Concrete sand is then admixed with gravel or crushed stone to bring the final product up to concrete aggregate standards.

4.0 Potential Impacts

There is little information available on the potential impacts of offshore aggregate mining in the U.S. Due to the dependence of offshore aggregate material overseas, there have been numerous studies and reviews of impacts for sand and gravel mining in these areas (*e.g.*, ICES 1995, 1996; Kenny and Rees 1994, 1996; de Groot 1981, 1986; Coastline Surveys Limited 1999). As a result, the discussion of impacts provided below relies heavily on studies conducted overseas.

The potential impacts from offshore aggregate mining will be similar to those described in Chapter 3 of the main report for dredging sand for beach nourishment projects. However, differences between the two operations such as a longer duration of mining for aggregates, a likely larger areal extent of mining for aggregates, and differences in benthic community composition will result in disparate impacts. The mining (or dredging) operation will cause direct impacts to the physical environment and biological resources within the dredged area due to changes in bottom topography and habitat. The dredging operation will remove sediment and any benthic organisms that are living within (infauna) and on the sediment (epifauna). It will also result in the deposition of disturbed sediment over undisturbed portions of the seabed and dispersion of particulate matter throughout the water column. Generally, the resuspension and subsequent settlement of sediments is a short-lived event with associated short-term impacts (Coastline Surveys Limited 1999). However, the recovery of the benthic community and habitat within the immediate dredged area is a longer term process dependent on several factors such as the areal extent of disturbance, physical processes, and the timing of the dredging operations.

The existing conditions described in Chapter 2 for the study area are pertinent to a discussion of potential impacts from aggregate mining. Specific potential impacts to these resources are described below.

4.1 Physical Environment

4.1.1 Geology

The siting of the mining operation is controlled by existing geological conditions, i.e., the location of the geomorphic features and geologic structures with available commercial reserves of aggregate material. The geologic conditions within an area will place constraints on the methodologies used to recover aggregate. The chosen methods, in turn, will impose method-specific environmental impacts and affect the cost of recovery and material processing.

Changes in Bathymetry

Dredging for aggregates will change the existing bathymetry at the source site. Dredging at a shoal may result in the total removal of this topographic feature. A bathymetric depression or pit may also result. If select areas of the shoal are mined (e.g., the crest), there will be an increase in the depth of the water column over these areas. Dredging of a relatively flat sand sheet would leave a pit or trench (Figure 3-8). Dredging to remove subsurface channel sands would also leave a pit on the sea floor.

Each of these changes will affect current patterns at the site. The manner in which current patterns could be modified are discussed in Section 3.3.2.3. Changes in existing current strengths and directions will, in turn, alter depositional patterns. Water movement in a pit may be reduced and lead to the development of anoxic conditions. The impacts of these changes to local water chemistry and biological resources are discussed in Sections 3.3.2.4 and 3.3.3, respectively. Diminished current velocities over a pit may promote the deposition of fine sediments. If the sediment supply is not sufficient to fill up the pit with either sand or fines, it will persist. On the other hand, changes in currents may result in the scour of pits and the removal of fine sediments.

Altered Bottom Substrate

The bottom substrate at and near the source site may be modified in several ways. A change in the hydrologic regime as a consequence of altered bathymetry may result in the deposition of fine sediments where there had been a shifting sand sheet environment.

Existing substrate characteristics may also be changed by the exposure of underlying sedimentary units. The removal of surficial or subsurface sand units may expose underlying material that has different textural and compositional properties than the existing surface substrate. The most drastic change would be from sand to mud. The impact of a substrate change to biological resources is discussed in Section 3.3.3.2.

The bottom substrate at a distance from the borrow site will also be modified by the deposition of sediments from benthic and surface plumes generated by dredging activities. Sediments contained within plumes produced from the disturbance and resuspension of bottom sediments, and from discharges of the dredging vessel and equipment, will settle out from the water column and be deposited at a distance from the dredge site. The deposition of resuspended sediments may result in a layer of sediment that differs from the existing substrate. The impact of plumes to water column chemistry and biological resources is discussed in Sections 3.3.2.4 and 3.3.3, respectively.

4.1.2 Air Quality

Construction aggregate processing involves many operations including resource extraction, offloading, conveying, crushing, screening, loadout, milling or grinding, drying, mixing, handling and storage, and transport to users.

Uncontrolled construction aggregate processing can produce nuisance problems and can have an effect upon attainment of ambient particulates (PM) standards. In general, the wet processing during operations of crushing and grinding, washing, and screening would prevent the generation of appreciable amounts of particulate emissions.

The major air quality concerns for the offshore aggregates industry include the potential impacts from dredging emissions, sand and gravel processing emissions, dusts from aggregate handling, storage piles and wind erosion. These emissions can be assessed by using the EPA developed *Compilation of Air Pollutant Emissions Factors, AP-42* and their updated documents.

Air Emissions from Dredging Activities

Offshore aggregate mining will likely be conducted by two methods - a TSH dredge equipped with drag-heads and a hopper; or a hydraulic cutter- suction dredge anchored at the source site. The dredged material would then be transported to the processing plant by barge and offloaded using a dry system (as opposed to pumping a slurry) consisting of, for example, scraper buckets which place the material on conveyor belts which carry it to open stockpile areas. The air pollutant emissions resulting from the dredging operations were described in Section 3.3.2.2. The critical nitrogen oxides (NO_x) emissions, as well as the smaller amounts of SO_2, VOC, CO and PM, from the offshore sand and gravel dredging operations generally remain unchanged for both end uses of the sands - either for beach nourishment or for construction aggregate processing – with the exception that aggregate mining will likely be a continuous operation for several years. Therefore, offshore aggregate mining will have similar effects on air quality as those of beach nourishment projects.

Air Emissions from Sand and Gravel Processing

While the emissions from offshore dredging operations remain similar for both proposed beach sand replacement and construction aggregates processing, the latter operation would result in the additional emission of air pollutants - mainly PM or dust emissions within the processing plant’s vicinity during processing - such as conveying, loading, unloading, screening, and crushing, as well as during handling activities and storage, or wind erosion.

The processing of sand and gravel involves the use of different combinations of washers, screens and classifiers to segregate particle sizes; crushers to reduce oversize materials; and storage and loading facilities. Sand and gravel processing operations and their resulting air emissions will be similar to those procedures and emissions at plants processing sand and gravel from land extraction in the region. Therefore, there would be no significant differences in air quality at existing processing plants whether they process land-based or offshore aggregate material. Furthermore, if the materials are wet or moist when handled in the plants, the process emissions (PM or dust) are often not appreciable.

Air Emissions from Aggregate Handling, Storage Piles, and Wind Erosion

Dust emissions or PM would occur at several points in the aggregate handling and storage cycles, such as material loading onto piles, disturbances by strong wind currents, and frequent material transfer into or out of storage. When freshly processed aggregate is placed onto a storage pile, the potential for dust emissions is at a maximum. Fines such as dredged sands could be disaggregated and released to the nearby environment upon exposure to air.

A study of the air emissions from open aggregate piles and wind erosion was conducted by examining the U.S. EPA's AP-42 emission factors and related documents for the two various types of sands - dredged sands with a typical grain size of 0.5 mm and 1.0 mm.

Results indicate that the PM or dust emissions releasing from a typical 600 m^2 surface area aggregate material open pile will be approximately 360 kg/year of particulates for 1.0 mm-sized sands and 792 kg/year of particulates for 0.5 mm-sized sands. The difference in PM emissions would come from the different threshold friction velocities of the wind shear stress on aggregates material piles formed by various types (finer or coarser) of sands. However, moisture can cause aggregation and cementation of fines to the surfaces of larger particles and greatly reduce the dust emissions from the finer sands.

Construction aggregates plants within the Mid-Atlantic region would be within PM attainment area while the estimated measurable PM emissions will be less than 1 ton/year for a typical offshore aggregate industry operation. These emissions which are far below the PSD (Prevention of Significance Deterioration) thresholds of 250 tons/year for the attainment areas, and therefore utilization of dredged sand or gravel in the offshore aggregate industry is not anticipated to have significant impacts on air quality.

4.1.3 Waves and Currents

A general discussion of potential impacts to the local wave regime caused by sand mining is provided in Section 3.4.2. Based on modeling as described in Section 3.4.5 which resulted in source zones of possible impact from severe and extreme waves, it appears that potential mining activities in the northern portion of the study area would not result in impacts to the local wave regime. However, as with dredging for beach nourishment, aggregate mining operations in the zones described in Table 3-4 and Figure 3-23 could result in impacts and would require further detailed studies.

4.1.4 Water Quality

Typically, dredges used for construction aggregate mining consist of TSH dredges or anchored hopper dredges. Trailing suction hopper dredges are the same as the dredges used for beach nourishment. Anchored hopper dredges are preferred for smaller localized deposits such as channel deposits.

Hopper overflow and the screening process are of primary importance in the establishment of dispersive plumes from marine aggregate mining (Hitchcock *et al.* 1998).

The following sections provide a brief discussion of the two methods with regard to water quality impacts.

4.1.4.1 Trailing Suction Hopper Dredging

As with offshore dredging of beach nourishment sand, construction aggregates are removed from the seabed through dragging of a suction pipe across the seabed. Davies and Hitchcock (1992) reported that the average cut depth in United Kingdom license areas ranges from 0.3 to 0.6 m; the average cut width ranges from 2.5 to 3.7 m depending on the size of the draghead and the sediment type. The infilling of the furrows cut by the dredgehead is dependent on hydrodynamic conditions at the site but typically takes at least 12 months (Oakwood Environmental 1998) or several years (*e.g.*, Millner *et al.* 1977; Kenny and Rees 1996; Desprez 1992), although storms and fast currents may fill the furrows within weeks or months (*e.g.*, Van Moorsel and Waardenberg 1990).

Potential water quality impacts from TSH dredges consist of the following:

- **Turbidity (if sediments are not screened at sea):** Turbidity is generated at the seabed ('benthic plume') and particularly from the overspill of the hopper ('surface plume'). The volume of material in the overspill from the vessel depends mainly on whether the mined material is processed on-board or on shore. If the material is processed onshore, the volume of suspended sediment discharged as overspill is approximately the same as for beach nourishment mining with a trailing suction hopper dredge (see discussion in Section 3.3.2.4.1 above).

- **Turbidity (if sediments are screened at sea):** In western Europe, it is common practice to screen out unwanted grain sizes at sea (MMS 1996). Screening has the effect of creating a larger amount of discharged sediments, potentially resulting in greater environmental impacts. In addition, screened finer sediment may ultimately cover up sand and gravel resources with a layer of unmarketable sediment (Nunny and Chillingworth 1986). On the other hand, screening allows the hopper dredge to transport more marketable material per trip. Further, disposal of the material after screening on shore is avoided.

  The treatment at sea of dredged sand and gravel materials for use as construction aggregate is typically confined to washing and sizing to remove undesirable grain size fractions and thereby increase the economic loading of the hopper (Cruickshank 1988; Tsurasaki *et al.* 1988). The mined aggregate flows through screens set up on-board. The sand to gravel ratio desirable for mining depends on market conditions. A marketable ratio is listed as 2:3 sand to gravel; therefore, for example, for a mined ratio of 7:3, half of the mined material needs to be discarded to achieve the more marketable ratio (NAS [1975] as reported in MMS 1993). Commercial cargo requirements reported by Hitchcock *et al.* (1998) consist of 35 to 70 percent gravel content, depending on requirements by customers. Grain sizes finer than 'very fine sand' (<0.125 mm) are considered a "nuisance" because they are not marketable (MMS 1996).

  The amount of discharged screened material depends on the grain size distribution of the sediments on the ocean floor and the desired grain size mix for the cargo. Hitchcock *et al.* (1998) stated that in the United Kingdom, dredgers discharge between 0.2 and 5 times the cargo load mined from the seabed. During one of the dredging runs, of a total of approximately 12,200 tons of dry solids recovered from the ocean floor, approximately 7,250 tons were discharged back to the sea after screening, 750 tons were discharged through overspill, and only a total of 4,200 tons were kept as cargo.

  Screened sediments discharged at sea settle out rapidly. Hitchcock *et al.* (1998) observed that the coarse sediment fractions (>2 mm) settle out instantaneously, possibly as density currents. Most of the remaining sediment in the plume settled out within 300 to 500 m from the dredge over a period of roughly 20 to 30 minutes. The suspended sediment concentrations returned to concentrations close to background in less than an hour after completion of dredging, depending on size and specific gravity of the material in the plume.

  Impacts from the surface sediment plume to benthic resources from aggregate mining are similar to impacts from beach nourishment mining (see discussion in Section 3.3.2.4.1 above) with the exception that a potentially much larger volume of sediment is discharged due to on-board screening of the sediment. Large volumes of sediment would result is higher sediment accumulation rates in the immediate vicinity of the dredger, thus resulting in potential impacts such as burial of the benthic ecosystem.

- **Other water quality impacts:** Other potential impacts from contaminated sediments, hydrogen sulphide, nutrients and petroleum hydrocarbons are minor and not expected to be a concern (see discussion in Sections 3.3.2.4.4 to 3.3.2.4.7 above for more details)

4.1.4.2 Anchored Hopper Dredging

Anchored hopper dredges lie on anchor during the dredging operation. The dredge pipe faces forward. The dredgehead may swing sideways in an arc or the vessel moves forward on the anchor line. Typically, this method of "stationary" dredging leaves behind deep pits in the seabed. On the east coast of the United States, anchored dredges are not commonly used. However, these types of dredges are included in this discussion on impacts in case future studies show that this form of dredging is the more appropriate method for sand and gravel mining for selected deposits on the Mid-Atlantic shelf. Impacts from anchored hopper dredging consist of the following:

- **Development of pits on the seabed:** Anchored hopper dredges may leave pits in the seabed with a depth of 20 meters and a width of 75 meters (Dickson and Lee 1972; Cruickshank and Hess 1975). These depressions may remain in place for several years depending on the local hydrodynamic conditions (Oakwood Environmental 1998). Filling will eventually occur through slumping of the slopes and gradual settling of suspended sediment. However, the filling of pits dug by anchor dredges may be slow and are highly dependent on current speeds and grain size, and the depth of the pit. In a study of a deposit of the Shingle Bank near England, Dickson and Lee (1973) found that the pits were still visible after two years. In the Dutch Wadden Sea, the recovery of pits ranged from 1 year in areas of high current velocities to 5-10 years in areas of lower current velocities (van der Veer *et al.* 1985).

- **Dissolved oxygen in the pits:** Depending on the hydrodynamic conditions at the location, the pits are likely going to act as sediment traps capturing sediments that are finer-grained than the sediment deposited in the surrounding areas. Such sediment would include organic particles. Inside the pits, low dissolved oxygen concentrations could develop particularly during summer months when oxygen concentrations in the water column are naturally lower. Low dissolved oxygen concentrations in the pits would impact the local fauna. Oxygen depletion would be enhanced if a dredge hole was to be filled with elevated concentrations of organic matter that consumes oxygen during decomposition.

- **Turbidity:** Turbidity would be generated at the seabed ('benthic plume') and from overspill from the hopper ('surface plume'). The impacts from the benthic plume would be local since the dredge moves only slowly. The impact on the seabed would be similar to the impact of the cutter suction head used for beach nourishment mining. The sediment accumulation rates due to the resettling of resuspended sediment in the immediate vicinity of the area of operation may be high, burying benthic organisms.

  The impact from the surface plume would be the same as the impact from the surface plume of the hopper dredge used for beach nourishment (see discussion in Section 3.3.2.4.1 above).

- **Other water quality impacts:** Other potential impacts from contaminated sediments, hydrogen sulphide, nutrients and petroleum hydrocarbons are similar to the impacts discussed in Sections 3.3.2.4.4 to 3.3.2.4.7 above.

4.1.4.3 Onshore Processing

Onshore, the sand and gravel deposits are cleaned of salt by washing and the deposits are sized further for sale of the product. Sand offloaded contains approximately 0.25 percent salt (Tsurasaki *et al.* 1988) which is higher than recommended for use in concrete. The American Concrete Institute Committee 201, Guide to Durable Concrete, recommends a limit for chloride ions in prestressed concrete of 0.06 percent (Portland Cement Association 1979) which is equivalent to a sodium chloride content of 0.10 percent; sodium chloride is by far the dominant salt contained in seawater. In Japan, the standard for salt in sand used in concrete for building construction is 0.04 percent or less; for concrete for other uses the maximum content is 0.10 percent (Tsurusaki *et al.* 1988). Washing may be done by various techniques including (a) sprinkling of freshwater onto the stockpiled mound of aggregate, and (b) mechanical washing (*e.g.*, Littler, 1990). During the washing process, fine grain sizes (silts and clays) contained in the material are removed together with the salt.

Water quality impacts from washing and further screening of the aggregate on shore could occur in the receiving environment of the discharged process water. Potential impacts include the following:

- **Turbidity:** High turbidity (*i.e.*, elevated suspended matter concentrations) in the discharged process water could potentially affect the benthic ecosystem in the vicinity of the discharge.

- **Salinity:** If the discharged process water is discharged into a freshwater body, impacts to the biological ecosystem could occur from the salt in the process water.

- **Aesthetic Impacts:** Elevated turbidity in the discharged process water would likely be transported for a certain distance as a plume from the point of discharge since the suspended matter is primarily fine-grained material. The distance is determined by the volume and concentration of sediment discharged and the local hydrodynamic conditions. Depending on the use of the waterbody and its surroundings, the plume of discharged process water could present an aesthetic impact, and possibly an economic impact in case the area is used, for example, for recreational activities or housing.

- **Dissolved Oxygen and Nutrients:** Depending on the concentration of organic matter in the suspended matter in the discharged process water, the dissolved oxygen concentration in the receiving waters could be affected if the water circulation rates are low. Elevated nutrient concentrations in the process water due to elevated organic matter concentrations could result in increases in primary productivity (*i.e.*, growth of algae) in the water column. However, the concentration of organic matter in offshore aggregate deposits is generally very low, thus impacts are not expected.

- **Contaminants:** If the mined aggregates contain contaminants, the contaminants would also be contained in the discharged process water. Contaminated sediments would pose health risks for user of the aggregate and workers of the mining operation. Therefore, contaminated aggregate deposits should not be dredged. Updated information about chemical contamination should be obtained prior to dredging either through a literature review or, if existing information is unavailable or insufficient, by a sampling program.

4.2 Biological Resources

The primary ecological impact of mining aggregate areas will be the complete removal of the existing benthic community through entrainment into the dredge. Mortality of the benthic infauna and epifauna will occur as they pass through the dredge pump and/or as a result of being transplanted into an unsuitable habitat. In addition, excessive siltation and increased turbidity associated with aggregate mining can result in impacts to marine organisms (Auld and Schubel 1978; Snyder 1976). Siltation and burial of benthic organisms and reef/hard bottom habitat is an issue of concern, and the increase in turbidity affects both filter-feeding organisms and fishes. Larval and juvenile fish, in particular, are especially sensitive to dredging-induced turbidity, as their gills may become clogged or abraded by floating particulates. Feeding ability of larval and juvenile fishes is decreased due to a reduction in available light.

The biological environment of the New York Bight is similar to the rest of the Mid-Atlantic Bight in terms of species composition and distribution. It is, however, significantly more impacted by anthropogenic disturbances than anywhere else on the east coast of the U.S. Offshore dumping of domestic and industrial waste materials occurred from the 1920's to the early 1980's, resulting in significant impacts to the benthic and pelagic biota of the New York Bight. It is important to note that the New York Bight from Manasquan Inlet, NJ to Long Beach, NY has been closed to shellfishing since 1974 (Draxler *et al*. 1996).

The mining of marine aggregates may have greater impacts to biological communities relative to dredging for beach nourishment sand in similar areas. The duration of aggregate mining in the proposed areas will be significantly longer than individual offshore dredging operations for beach nourishment projects. Aggregate mining will encompass several years of continuous dredging, significantly increasing the degree of impacts to resident biota. The relative size of potential aggregate source areas is also significantly smaller proportional to the sand habitats of the Mid-Atlantic Bight. Dredging in aggregate areas would have a greater impact because a greater proportion of the overall habitat would be effected. Impacting a significantly greater extent of a habitat would severely limit the rate of recovery of the species residing in the aggregate.

Biological communities found in aggregate sediment types are typically more complex (*i.e.*, greater species diversity, different species composition, increased trophic interactions) compared to communities found in smaller particle size sediments such as sand. Impacts to aggregate communities could also be greater due to the fact that more complex communities typically recover at slower rates than less complex communities (Oakwood Environmental Ltd. 1998; Newell *et al*. 1998a).

4.2.1 Plankton, Neuston

The increased turbidity and siltation associated with aggregate mining can impact larval fish and invertebrate abundance from clogging or abrading of gills or from direct mortality through suction in the dredge itself (Oakwood Environmental Ltd. 1998). Potential impacts to phytoplankton and zooplankton include the inability to photosynthesize due to decreased sunlight or decreased foraging efficiency. Van Dolah *et al.* (1992, 1994) observed, however, that the naturally high densities of phytoplankton, zooplankton, and larval organisms found in coastal waters are not significantly impacted by dredging activities. They calculated that the potential mortality caused by dredging did not equal the natural mortality rates of the populations under normal circumstances.

Because marine aggregate mining would likely be conducted year-round, the impacts to plankton and larval fish may be greater. Impacts would be greatest during times of the year when densities of organisms would be at their highest (spring through late fall). These impacts would also extend continuously over several years. Localized, short-term impacts could be significant during dredging phases, but such impacts would not be significant to plankton and larval fish populations in the long-term due to the relatively small area that is being impacted (Van Dolah *et al*. 1992; 1994).

Dredging and transport of marine aggregates could also lead to a relatively greater release of fine grained silts back into the water column through longer overflow times (Oakwood Environmental Ltd. 1998). Aggregate dredging would occur with a hopper dredge, a less efficient dredging technique when mining aggregate materials. Longer periods of dredge overflow, associated with increased amounts of water in the dredge material and longer settling times in the dredge itself, would increase the turbidity plume associated with the dredge. This increase in turbidity may increase impacts to larval fish and plankton through gill clogging and gill abrasion.

4.2.2 Benthos

Organisms living in the sediments being mined from outer continental shelf sites will be removed and/or destroyed. The aggregate source areas being dredged will be recolonized by adult organisms from adjacent areas or by recruitment of larval and juvenile organisms from the surrounding area (Newell *et al*. 1998). The rate at which a borrow area recovers and the degree to which the community returns to its original density and species composition is dependent upon the duration and timing of the dredging, sediment composition of the borrow area (Newell *et al*. 1998a), the hydrodynamics of the dredged pit or trench and surrounding area, the degree of sedimentation that occurs following dredging (Oakwood Environmental Ltd. 1998; Van Dolah *et al*. 1992), and the type of dredging equipment used to remove the sediment (Oakwood Environmental Ltd. 1998; Blake *et al*.

1996). Marine aggregate mining would naturally be expected to have a greater and longer impact on benthic invertebrate communities relative to dredging for beach nourishment projects, due to the extended period of disturbance that aggregate mining would occur.

Abundance, biomass, diversity, and species composition are significantly decreased immediately following dredging activities (Newell *et al*. 1998a; Schaffner *et al*. 1996). Following dredging, borrow areas are quickly recolonized (1 month to 1 year) (Schaffner *et al*., 1996) by opportunistic species (i.e., *Streblospio* sp., *Capitella* sp., *Ampelisca* sp., *Owenia* sp., *Scololepis* sp., *Chaetozone* sp., *Corophium* sp.) (Newell *et al*. 1998). These opportunistic species (characterized by rapid growth and reproduction) may not be the same species that were present in the area prior to dredging and in most cases are smaller individuals living in only the top few centimeters of sediment (Newell *et al*. 1998a). If the aggregate source area is not impacted by continued dredging, unusually high sedimentation rates, or some other disturbance, a natural succession of species composition should occur, potentially restoring the area back to its original levels of abundance and biomass within 1-5 years (Van Dolah *et al*. 1992; Blake *et al*. 1996; Newell *et al*. 1998a).

Kenney and Rees (1994, 1996) reported on the benthic recolonization and recovery of a gravel deposit mined with a suction trailer dredge off Lowestoft, Norfolk in the southern Northern Sea. They conducted a monitoring program over the first seven months after dredging (Kenney and Rees 1994) and subsequently for two years after dredging (Kenney and Rees 1996). They reported some recovery within the first seven months after dredging. Two years after dredging, there was recruitment of new species, especially reselected species. However, even two years after dredging, average species abundance and biomass for the dredged area were lower than those in the reference site.

Dredging in aggregate (coarse grain size) areas potentially impacts existing benthic communities to a greater extent than mining in other sediment types (Oakwood Environmental Ltd. 1998; Newell *et al*. 1998). Aggregate dredging can expect to result in a 30-70% reduction in species diversity and 40-90% reduction in both number of individuals and biomass (Newell *et al*. 1998). Recovery of borrow areas for aggregate material takes considerably longer than the recovery of sand or silt borrow sites (2-10 years). The increase in recovery time is associated with sediment stability (more stable sediments lead to more complex communities that require longer periods of time to recover). The area may not recover to its original species composition because of changes in sediment composition and potential changes in competition between species.

Newell *et al*. (1998a) observed that borrow areas at higher latitudes recover at slower rates than borrow areas at lower latitudes. They also note that relatively weaker currents through a borrow pit could decrease the rate of recovery to as much as 2-8 years and that borrow areas with silt bottoms recover faster than pits with sand and gravel sediments. These authors also observed that there is little evidence of dredging operations affecting the biota in the areas adjacent to borrow areas. A recent investigation into the effects of aggregate mining on marine benthos found that the resuspended sediments associated with aggregate mining do not significantly impact benthic communities outside the immediate dredging area (Hitchcock *et al*. 1998).

If the characteristics of the site are changed by dredging such that the mined area fills in with a different type of sediment (e.g., silt vs. clay), or the currents through the area are altered by the change in topography, the rate of succession could be changed allowing different species to recolonize the area, or allowing certain species to exclude other species through competition (Van Dolah *et al*. 1994; Wilber and Stern 1992; Schaffner *et al*. 1996). The longer duration of activity associated with aggregate dredging would have a greater probability of altering the sediment characteristics, and therefore the species composition, of the area being mined.

Overall, dredging significantly impacts the benthic organisms living in the sediment of the area being mined. These impacts are only short-term, however, and recolonization of borrow areas begins almost immediately following dredging. In the long-term the borrow area will recover to original densities of organisms, but not necessarily to its original species composition. Impact to a potential borrow area can be minimized by first considering whether or not the community that is present is unique or of particular significance to the ecology or economy of the shelf (*e.g.,* offshore of southern New Jersey). If the resident community is of importance, it may need to be avoided. Timing and duration of dredging to coincide with intervals of low abundance and diversity of organisms will also minimize potential impacts to an area (Oakwood Environmental Ltd. 1998).

4.2.3 Fish

Potential impacts to juvenile and adult fish include direct burial and gill clogging or abrasion. Only the less motile species of fish, or those that feed exclusively on non-motile organisms, are expected to be impacted by dredging efforts (Van Dolah *et al*. 1992). Most other species will leave an area while dredging occurs, significantly decreasing their abundance and diversity for the short term, and will return to the dredged area shortly after dredging is completed. Available food sources (*i.e.,* benthic invertebrates) could be significantly depleted during dredging and may affect the foraging success of bottom feeding fish (Oakwood Environmental Ltd. 1998). Depending on the recovery rate of the benthic communities in the dredged area, this may have short-term or long-term effects on fish distributions in a specific area. Van Dolah *et al*. (1994) observed that even though species diversity and abundance were significantly lowered by dredging efforts, the mined area had completely recovered to its original species densities and composition within six months.

The fish populations impacted by marine aggregate mining would be able to avoid direct impacts from the physical dredging process. Indirectly, however, fish populations could be significantly impacted through extended depletion of benthic food sources and loss of potential habitat. The area being dredged would not offer suitable foraging habitat during the mining activity. The area would require several years after mining had ceased before demersal fish populations would be expected to return to previous levels of abundance and species composition.

4.2.4 Non-Endangered Marine Mammals

The potential impacts of offshore dredging activities are generally similar for all of the species of marine mammals described in Chapter 2. Potential impacts include disturbance to benthic and aquatic habitats and disruption of the prey base, interference with filter feeding, noise disruption, and potential collisions between equipment or transport vessels and marine animals. Certain types of impacts, such as vessel collisions, are more likely to affect certain species which have surface feeding or resting habits, such as right and humpback whales. Noise associated with dredging operations may have a greater affect on species that are sensitive to low-frequency sound than on species with different optimum hearing ranges. Rather than analyze the different hearing ranges of all marine mammals in the project area, it should be assumed that noise will cause avoidance responses to some degree in all species.

Overall, the continental shelf off the Delmarva peninsula in the Chesapeake Bay region harbors the greatest concentration of marine mammals and sea turtles in the mid-Atlantic, particularly during the spring and summer months. As described in Chapter 2, mid-shelf east of the Chesapeake Bay region is a high use habitat for marine mammals, with piscivorous species generally concentrated off the coasts of Delaware and Maryland during these seasons (Kenney and Winn 1986). This area is primarily used as foraging and developmental habitat by these animals, rather than for breeding. In these areas, disruptions to the prey base are likely to have more significant impacts than in other, less frequently utilized habitats. Food items of marine mammals include benthic fauna, plankton, fish, and squid. Dredging for sand can affect the ability of marine mammals to obtain food in several ways. The most evident impact is a substantial initial reduction in the benthic invertebrate fauna in the dredged area (USACE 1998d). Dredging operations can cause the animals to avoid particular feeding areas due to noise or vibrations. Decreased feeding success and prey availability may occur in areas of increased activity-related turbidity. Turbidity plumes caused by sand mining can affect species of concern and their prey in a variety of ways. Decreased visibility can affect foraging ability by those species that use sight as a primary means to locate prey. Plankton growth may be affected by the decrease in light levels caused by the presence of a fine sediment plume. However, studies that have attempted to assess the extent of plankton resource entrainment during the hydraulic dredging of sand borrow areas have not identified significant impacts (Van Dolah, *et al*. 1992, 1994). Particulate matter may have deleterious effects on filter feeders and gilled organisms, although many mobile, free-swimming organisms such as pelagic fish can avoid turbid areas (NRC 1985).

These effects can also be expected outside the immediate vicinity of the dredging activity. Sand and gravel operations using hopper dredges tend to be discontinuous and associated plumes would be dispersed over a larger area. However, because the concentration of the suspended particles in the plume diminishes rapidly with time and distance from the source, the effects on fauna further away from the activity are reduced. In general, the effects of turbidity on phytoplankton (due to light reduction) or on pelagic fish and invertebrates (due to gill irritation and reduction of light levels for visual feeders) are considered small (MMS 1993). Within the water column, the effects of particulates on the drifting biotic communities are considered negligible because of the limited area affected and the typically short exposure time (NRC 1985). A suction hopper dredge is usually on-site for three to four hours during a 24 hour period, with the remaining time spent in travelling and unloading sand (Drinnan and Bliss 1986). This discontinuous method of sand-mining allows suspended sediments to dilute, dissipate, and settle.

Many of the potential effects upon marine mammal prey species as described above would be considered indirect impacts. Direct impacts from offshore sand mining can also occur. The most severe would be death or injury caused by collisions with activity-related equipment or support vessels. Some marine mammals that sleep or rest motionless at the surface, or that are slow swimmers, may have difficulty avoiding fast-moving vessels. Right whales in particular are susceptible to vessel strikes.

Noise is byproduct of any offshore operation that can also directly affect marine mammals by altering normal behavior patterns. Some researchers have suggested that most marine mammals become habituated to low-level background noise, such as ship traffic and offshore petroleum activities, however some animals show abrupt responses to sudden disturbances (MMS 1993). Stationary dredging operations in the arctic did not greatly disturb beluga and bowhead whales, but their swimming patterns did change within 2.4 km of dredging operations (MMS 1983). It may be difficult to eliminate all noise effects if activities are proposed in sensitive habitats.

4.2.5 Sea Turtles

The potential impacts to sea turtles by offshore dredging activities are similar to those described for marine mammals above. Potential impacts include disturbance to benthic foraging habitats and disruption of the prey base, interference with underwater resting habitats, noise disruption, and potential collisions between equipment or transport vessels and marine turtles. The period of greatest sea turtle activity in the project area is spring and summer, during which time numerous, mostly juvenile sea turtles, particularly loggerheads, Kemp's ridleys and leatherbacks, forage in the back bays and shallow waters of the Chesapeake and Delaware Bays and off the coast of New Jersey. Sea turtles feed on benthic invertebrates, fish, crabs, jellyfish, sponges, and sea grasses. Dredging in shallow areas can destroy foraging habitat for sea turtles. Farther offshore, drifting beds of *Sargassum* seaweed are used by hatchling turtles as nursery habitat. These beds occur in areas where different tides converge and sink. Disturbance of such beds of seaweed removes potential juvenile turtle habitat and may harm hatchlings inhabiting them.

Direct impacts to sea turtles are also similar to those described for marine mammals. Controlled experiments with loggerhead turtles showed avoidance responses to low-frequency sounds (O'Hara 1990). Collisions with vessels are a particular concern for marine turtles because they mate, bask, and forage on the surface. Between 1986-1993, about nine percent of stranded sea turtles (living and dead) off the coast of Florida had propeller or other boat strike injuries. Vessel strikes were determined to be an important cause of sea turtle mortality. (Lutcavage *et al.* 1996). In the Chesapeake Bay, boat propeller wounds accounted for seven percent of deaths of sea turtles stranded between 1979-1988, or five to seven turtles per year. It is estimated that approximately 400 sea turtles per year are killed by boat collisions off coastal beaches (NRC 1990). Another serious impact to sea turtles is entrainment in hopper dredges. The use of hopper dredges can kill turtles caught in dragheads. In Florida, there were 149 confirmed incidents of sea turtles entrained by hopper dredges working in two shipping channels from 1980-1990. Nearly all turtles entrained by hopper dredges were dead or dying when found (NRC 1990).

4.2.6 Threatened and Endangered Species

Threatened and endangered species in the project area include all sea turtles described in Chapter 2; the blue, fin, humpback, right, and sperm whales; the shortnose sturgeon and the sand tiger shark. Potential impacts to all marine mammals and sea turtles have been described in the sections above.

Similar impacts related to turbidity plumes including loss of benthic food supply through siltation and displacement of organisms, gill abrasion from suspended sediments, and loss of habitat through alteration of bottom features may effect shortnose sturgeon and sand tiger shark. Habitat alterations from discharges, dredging or disposal of material into rivers, and related development activities involving estuarine/riverine mudflats and marshes are known threats to shortnose sturgeon (NMFS/USFWS 1998). Shortnose sturgeon spawn in late April in the lower Hudson, but are found from the Gulf of Maine to northeast Florida. Because shortnose sturgeon do not breed in offshore marine areas, impacts to this species caused by offshore dredging activities are expected to be relatively minor or insignificant. Natural shoal areas, like Hen and Chicken Shoal, have been documented as possible nursery sites for sand tiger sharks. Sand tiger sharks are currently being identified as candidates for possible addition to the List of Endangered and Threatened Species. This area could be designated closed in the near future (J. Tinsman, Delaware Artificial Reef Program, pers. comm., Feb. 1999). Even though sand tiger sharks are somewhat sluggish, it is expected that they could readily avoid the other areas affected by sand mining activities.

4.3 Socioeconomic Environment

4.3.1 Commercial and Recreational Fisheries

Potential impacts to commercial and recreational fisheries will be similar to those described in Section 3.3.4.1. However, since marine aggregate mining may require year-round commitment to be cost-effective, the potential impacts to commercial and recreational fisheries will be intensified. A project duration of several years would preclude any type of fishing within the mining area and its immediate vicinity. Recreational fisheries will be least affected since targeted species are motile and can avoid the area of activity. Possible loss of structural habitat due to burial could arise, creating a shift in recreational fishing locations or intensified catch effort at other hard bottom habitats. Other factors that may affect this fishery stem from noise and turbidity associated with mining activity but would have minimal impacts to pelagic species.

Commercially, the demersal fisheries are of primary concern due to the fact that loss of habitat would directly affect harvest and would possibly increase catch efforts elsewhere to obtain normal quotas. This migration or lack of commercial fishing grounds could introduce new, intensified anthropogenic stresses to previously unexploited benthic populations and communities. Fisheries directly affected by sand mining operations are the surfclam, lobster, ocean quahog, scallop, winter flounder, and summer flounder. Burial of surrounding habitat, changes in substrate grain size from the continuous resettlement and resedimentation of particulates associated with mining operations, loss or degradation of localized benthic habitat, and the possible creation of new habitat are all underlying factors that lead to the disruption and possible loss of productive fishing grounds. Recently, there has been concern with the decreased integrity of lobster habitat caused by sediment migration from beach nourishment projects in New Jersey (T. McCloy, NJDEP Division of Fish, Game and Wildlife, pers. comm., May 1999). The constant mining could create similar effects with sedimentation from consistent benthic or surface plumes.

Future recruitment of a viable commercial stock could be hindered locally through the process of entrainment. This can be more detrimental to sessile, benthic communities. Pelagic larval stages of shellfish and the peak periods of larval settlement should be assessed. Since the project area is so vast (encompassing the entire mid-Atlantic) variances in bathymetry and water temperature are evident. These variances effect the peak spawning periods for shellfish like the surfclam. Surfclams ideally prefer water temperatures below 22.8 degrees Celsius (Saila and Pratt 1973) which partially determines their southerly distribution veering more offshore than their northerly inshore distribution. Optimum temperature for larvae is 21.7 degrees Celsius. Spawning occurs inshore in the spring and offshore in the fall for surfclams and is, as previously stated, temperature dependent. Fertilized ova develop into pelagic larvae and settle to the substrate approximately 19 –35 days after fertilization based on temperature (Fay *et al*. 1983d). Maturation rates vary after settlement and are based on minimum shell lengths. The entrainment of demersal eggs (winter flounder), pelagic eggs, pelagic shellfish larvae, spat or settled larvae, and juvenile stocks could inevitably affect future harvests, in turn, diminishing future revenue.

The creation of deep pits from sand mining operations could create anoxic environments or pockets in which certain species populations (*e.g.* surfclam) would be adversely affected. Hypoxic events in New Jersey (DO levels less than 3 mg/g) have killed surfclams (Ropes *et al*. 1979) and may initiate spatial and temporal alterations in growth rate (Weinberg and Helser 1996). This could also result in a migration of commercial fishing grounds or commercial harvest based on population abundance and maturity applying fishing stress to adjacent unexploited stocks. Garlo (1982) determined one positive effect of hypoxia, the decimation of surfclam predators, which allows for the successful recruitment of newly settled juvenile clams. Yet, due to the longevity of mining operations, settlement in adjacent areas could be hindered due to the change in ocean current created by the change in bathymetry.

4.3.2 Artificial Reefs

As described in Sections 2.2.8.2 and 3.3.4.2, artificial reefs provide important habitat for a variety of fish species and provide opportunities to recreational fishermen. The location of reefs would preclude mining.

4.3.3 Archaeological and Cultural Resources

Activities which may affect offshore historic and archaeological sites include dredging and anchoring. Potential submerged cultural resources in coastal areas include shipwrecks as well as fortifications, early historic coastal settlements, and prehistoric sites that have become inundated through coastal subsidence, migration of shorelines and beaches, and the rise in global sea levels since the end of the last ice age. The majority of these potential resources are in estuaries or near the coastline within state jurisdiction, rather than in the project area which is in excess of 3 miles from the present shoreline. Cultural resources that are possibly located in the project area–on the OCS–include shipwrecks and unidentified remains of Native American occupation dating from circa 12,000 to 3,000 years ago.

In general, sand and gravel deposits would have a low potential for containing preserved archaeological sites. Coarse-grained sand and gravel represent high energy deposition that would have eroded rather than preserved remains of Native American occupation.

As a federal agency, the MMS ensures that its undertakings do not adversely affect potentially significant historic properties. To achieve this goal, the NOAA and the MMS maintain a database on historic shipwrecks. This database should be consulted prior to approval of any dredging operation and if a proposed action will potentially impact a historic shipwreck, a remote sensing survey may be performed to determine a more precise location of the remains so that they can be avoided. In addition, site specific studies to evaluate the potential for prehistoric sites should be conducted. The evaluation of a specific aggregate site soul include review of geologic, seismic, bathymetric, and geologic core logs to determine whether any well-preserved geomorphic features having potential for prehistoric sites are present within a proposed mining area. It would also need to be determined whether the proposed mining operations would affect these features and if so, a mitigation plan (avoidance or further investigation) would have to be implemented.

4.3.4 Infrastructure

Major submarine cables and pipelines are charted (Figures 2-84 to 2-87). Not all cables and pipelines are required to be buried, but may either rest upon the substrate or may be partially exposed due to shifting sediment. Caution should be utilized in any suspected cable or pipeline areas when gear is being used. Since there is a recommended one nautical mile buffer zone emanating from both sides of existing TAT cables, aggregate mining should not be conducted in these regions and should have a minimal impact to existing cables. If uncharted cables are encountered, gear could be compromised and cables could be damaged resulting in costly reparations. Familiarity of the bathymetry in areas of possible sand mining operations is necessary to reduce the risk of gear damage and crew jeopardy.

4.3.5 Shipping/Navigation

Aggregate mining can be accomplished in areas of high volume vessel traffic as evidenced by the current operations in the Ambrose Channel in Raritan Bay, New Jersey. The proper day signals or navigation lights for the dredging vessel should be visible during the appropriate times of day and must comply with 72 COLREGS requirements. The 1972 International Rules of the Road (72 COLREGS) govern the color, placement, range of visibility, and use of lights and shapes on all seagoing vessels and apply to all vessels operating on U.S. waters outside inland demarcation lines.

Designated areas of high traffic are the Chesapeake Bay, Delaware Bay, and New York/New Jersey Harbor areas. Commercial and private vessels of varied tonnage frequently transit these areas and their movements should be taken into consideration to maximize crew and vessel safety. Types of vessels that may be encountered include tugs in-tow, barges, passenger vessels, tankers, commercial fishing vessels, sailboats, dredgers, and an array of private, recreational vessels. The small bays and harbors that dot the shoreline of the Mid-Atlantic region also have large amounts of vessel traffic, including clam dredges, trawlers, pleasure craft and headboats. Since dredging operations might potentially be conducted outside of state waters in areas of low vessel congestion, the disruption of normal traffic flow from the correlating traffic schemes should remain unhindered. However, the vessels being utilized for sand mining operations will contribute to the overall traffic volume when travelling to and from site locations which could possibly increase chances of navigational mishap.

4.3.6 Military Areas

Military areas are described in Section 2.2.8.6 of the main report. Areas deemed as "danger areas" and those regions containing ordnance should be avoided if possible. Known areas of potential hazard are documented on NOAA nautical charts yet, unknown areas do exist. In areas of suspected danger, caution should be administered. Literature relating to periodicity and duration of military activity for various localities of the study area should be reviewed on a regular basis. Information pertaining to military activity and to those regions of prospective closure or limited access are updated in the monthly publication of *Notice to Mariners* and generalized in the appropriate Coast Pilots.

Failure to remain informed to the most recent updates of military areas and newly discovered danger areas could jeopardize crew safety and compromise gear.

4.3.7 Dredged Material Placement Sites

The location of present and historic dredged material placement sites within the project area are described in Section 2.2.8.7 of the main report. These areas should not be affected since they lack the aggregate sediment being sought and contain potential contaminated material. Therefore, there should be no direct or indirect impacts to dredged material placement sites.

5.0 Cumulative Impacts

Cumulative impacts are defined by the Council on Environmental Quality (CEQ) as "*…effect on the environment which results from the incremental impact of the action when added to other past, present and reasonably foreseeable actions regardless of what agency or person undertakes such other actions. Cumulative effects can result from individually minor but collectively significant actions taking place over a period of time.*" (CEQ – Regulations implementing NEPA, 40 CFR 1508.7, 1508.8, 1508.25). There are a number of ways in which cumulative effects may originate (NRC 1986). These include:

- *Time crowded perturbations* – repeated occurrence of one type of impact in the same area;
- *Space crowded perturbations* – a concentration of a number of different impacts in the same area;
- *Synergisms* – occurrence of more than one impact whose combined impact is greater than the sum of the individual parts
- *Indirect impacts* – those caused by, produced after, or away from the initial perturbation
- *Nibbling* – a combination of all the above taking place slowly and incrementally or decrementally.

With dredging offshore areas for beach nourishment sand, there will be a concern for potential cumulative impacts as a result of repeated dredging in borrow within short periods of time such that the benthic community, in particular, does not have sufficient time to recover. In addition, dredging areas close to one another may result in impacts to potential adult recruitment to the dredged area, further lengthening recovery time. Cumulative impacts will need to be considered and addressed during any proposed beach nourishment project.

The potential cumulative impacts of dredging operations for aggregate material will need to be examined in light of other activities in the immediate and surrounding dredge area. These will include commercial fishing, dredged material disposal operations, military activities, and other activities which disturb the benthic community and which indirectly impact organisms which utilize the benthos as prey. Cumulative impacts could have an economic consequences if they affect commercially important species such as surfclams. In addition, the potential cumulative impacts on physical processes, such as the potential replenishment of shoals through natural processes, should be addressed.

Oakwood Environmental Ltd. (1998) prepared documentation examining the cumulative effects of marine aggregate mining in the United Kingdom. They discuss the development of temporal and spatial boundaries and a determination of resource threshold to impact which will be required to properly assess potential cumulative impacts.

6.0 Mitigation Measures

6.1 Bathymetry and Lithology

The magnitude of potential impact will be diminished if the amount of material removed constitutes a small percentage of the total volume estimated for a source area. Dependent upon the volume of material to be extracted by a particular mining operation, it may be appropriate to rotate specific mining areas over time to avoid significant disturbances to the dynamics of the system. The use of sites should be prioritized to minimize impacts.

Monitoring of mining areas will be an important component in minimizing the impacts to the system. Of particular importance will be documenting any changes in the erosion and sedimentation/accretion patterns.

6.2 Air Quality

The main potential effect to air quality from mining operations are NO_x emissions, therefore the mitigation objective should be to keep projected emissions below the level that would trigger a conformity determination. This would include the use of engines that are relatively clean burning and avoidance or reduction of mining activities during the ozone season (usually June through September). The latter measure would be difficult for an operator to implement from an economic standpoint. In addition, the operator would need to track emissions by keeping records of fuel consumption.

If NO_x emissions are predicted to exceed the conformity threshold, the sponsoring agency (MMS) must consult with the appropriate State and local regulatory agency to assure that the emissions conform to the SIP.

6.3 Current Patterns and Circulation

Aggregate source areas should be selected to minimize potential changes in coastal wave environment (i.e., wave height, breaking wave angles, and associated longshore transport). This can be determined through wave modeling efforts (e.g., REF/DIF S) of potential sites similar to that which has been applied to the Sandbridge Shoal area off Virginia Beach, Virginia (MMS 1998).

6.4 Water Quality

6.4.1 Turbidity Reduction during Dredging

Mitigation measures to protect the water quality of offshore waters are the same as listed above for hopper dredges used for beach nourishment mining (see Chapter 4.0 - Mitigation). However, additional turbidity reduction measures may apply for mining of construction aggregates if screening of undesirable grain sizes occurs on-board the vessel.

The key to minimizing impacts from discharged sediments from hopper dredges is to keep the volume of discharged material as low as practical. Additional operational procedures for turbidity reduction for dredges that screen material include the following measures:

- Visual monitoring of the dredged material during loading by the Dredging Master. If the material consists of predominantly undesirable fines, loading should be ceased.

- Record keeping of the position of areas with predominantly undesirable fines to avoid during future dredging runs.

- Nunny and Chillingworth (1986) recommended to outfit the draghead with sediment quality sensors that would recognize sediment with undesirable grain sizes to avoid discharge of sediment after screening on-board.

6.4.2 Mitigation Measures for Onshore Facilities

Mitigation measures for processing facilities on shore are highly site-specific and should be investigated as part of a site-specific environmental assessment prior to the startup of onshore processing operations.

6.5 Benthos

The majority of unavoidable impacts from the dredging operations will be to the benthic community. Measures to minimize potential effects of dredging in an aggregate source area or areas include dredging in a manner to avoid creation of deep pits, alternating locations of periodic dredging, and conducting dredging during months of lowest biological activity.

In the *Ocean City, MD, and Vicinity Water Resources Study Draft Integrated Feasibility Report and EIS* (USACE 1998a), the USACE reported that a February/March dredging cycle would occur slightly before a natural spring season benthic recruitment peak. Repopulation of the benthos was expected to occur rapidly after the spring placement operation as the natural cycle of recruitment and growth is high during this period. In contrast, if an October/November dredging occurred it was expected that benthic repopulation would be slower due to the lower rate of recruitment at this time of year. Benthos from adjacent non-disturbed areas would be expected to repopulate the disturbed areas at both times of year.

In addition, rotational dredging may minimize frequent, repeated disturbance of a particular area, thereby allowing recolonization of benthic organisms to occur over a longer period of time.

Implementation of a benthic monitoring program concurrent with the project would document impacts and aid in avoiding impacts to sensitive areas.

6.6 Non-Endangered Marine Mammals

As described in Chapter 2, several species of marine mammals occur throughout the project area. Collisions with marine mammals can be eliminated or significantly minimized by requiring or encouraging reduced boat speeds in areas known or suspected concentrations of these animals or when animals are sighted in the vicinity of a vessel. In addition, restricting dredging to daylight hours will minimize the risks of strikes. In addition, NMFS-approved whale spotters/observers should be stationed on the dredger to minimize the risk of ship-strikes of whales.

6.7 Threatened and Endangered Species

The risk of entraining and destroying sea turtles in a dredge can be minimized by the selective use of, and modifications to, dredging equipment and methods. Coordination with the NMFS will be required. Typically, the use of properly installed and operated approved sea turtle deflectors (*e.g.*, WES designed diamond shaped deflectors) to minimize significant adverse impacts to sea turtles in the area and use of NMFS approved observers to monitor dredge operations would minimize potential impacts

The preparation of a Biological Assessment for review by the NMFS would likely be required to address potential impacts to the threatened and endangered species within a specific project area. To expedite future specific aggregate mining projects within the project area, an area-wide Biological Assessment addressing potential impacts to threatened and endangered species from offshore mining operations could be considered.

6.8 Commercial and Recreational Fisheries

Of particular concern within the study area is the potential adverse impacts that aggregate mining could have on commercially and recreationally viable species. Since the study area is vast and bathymetry varies with geography, each potential borrow site should be assessed individually to determine regularity of fishing, benthic biodiversity, targeted species population densities, biomass, and distribution before the area is utilized for sand mining operations. Commercial fisheries of concern are surfclam, lobster, summer flounder, winter flounder, scallop, and ocean quahog. Mitigation should be determined based on the potential species impacted within the aggregate source area. As noted in Chapter 2, the fishing for surfclams has migrated and landings have been concentrated off Atlantic City, New Jersey for the past few years (NMFS 1998). In addition, the waters off Ocean County, New Jersey (Point Pleasant, Island Beach, and Long Beach Island) are also a major harvest area and recently, the surfclam harvest off Cape May County has increased significantly. Commercial surfclam areas should be avoided and omitted during selection processes for potential resource sites. In addition, testimony provided at recent public hearings in New Jersey, has revealed concern about the loss of offshore lobster habitat due to the migration of beach nourishment materials from projects in Monmouth County (T. McCloy, NJDEPE, pers. comm., May, 1999). The areas of concern should be determined and monitored to determine any changes in sediment type or decrease in lobster abundance.

Due to the duration of aggregate mining, preliminary site assessment is critical to obtain localized data in reference to fishing regularity, catch amounts, biomass of targeted species, and distribution and concentration of the specific species on site. Possible monitoring could involve commercial fisheries surveys to record past and present catches, days at sea, and areas fished. Public hearings addressing fishery issues relevant to sand mining operations should be established. This could help determine minimal economic impact to the fishing industry caused by aggregate mining and could also determine suitable, cost effective periods to perform aggregate mining. These identified areas could then be either avoided totally or utilized when the commercial fishery is less prevalent.

Since little research has been conducted on recovery rates of offshore benthic communities in a coarse-grained environment, post-dredge monitoring of sites would be necessary. Monitoring would allow determination of the degree of adverse effects on various benthic populations and will determine the length of time for the affected populations to recover and form a commercially viable assemblage. Average recovery rates vary from six months to five years due to hydrodynamic conditions and resettlement rates of opportunistic benthos. Peak spawning times for all commercially viable demersal species should be considered before any operations commence and settlement periods for shellfish should also be evaluated. Mining should be conducted during periods when spawning and settlement of shellfish is minimal or in areas where species concentration is decreased.

Recreational fisheries require less monitoring since the majority of targeted species are pelagic and can avoid areas of dredge operations. The possible burial of underwater habitat structure associated with dredging operations could adversely affect marine habitat frequented by recreationally sought species. The Rules on Coastal Zone Management for New Jersey define shipwrecks as special marine habitat. Disturbance to or loss of these structures requires compensation with the creation of artificial reefs of equal habitat value (T. McCloy, NJDEP, pers. comm, May, 1999).

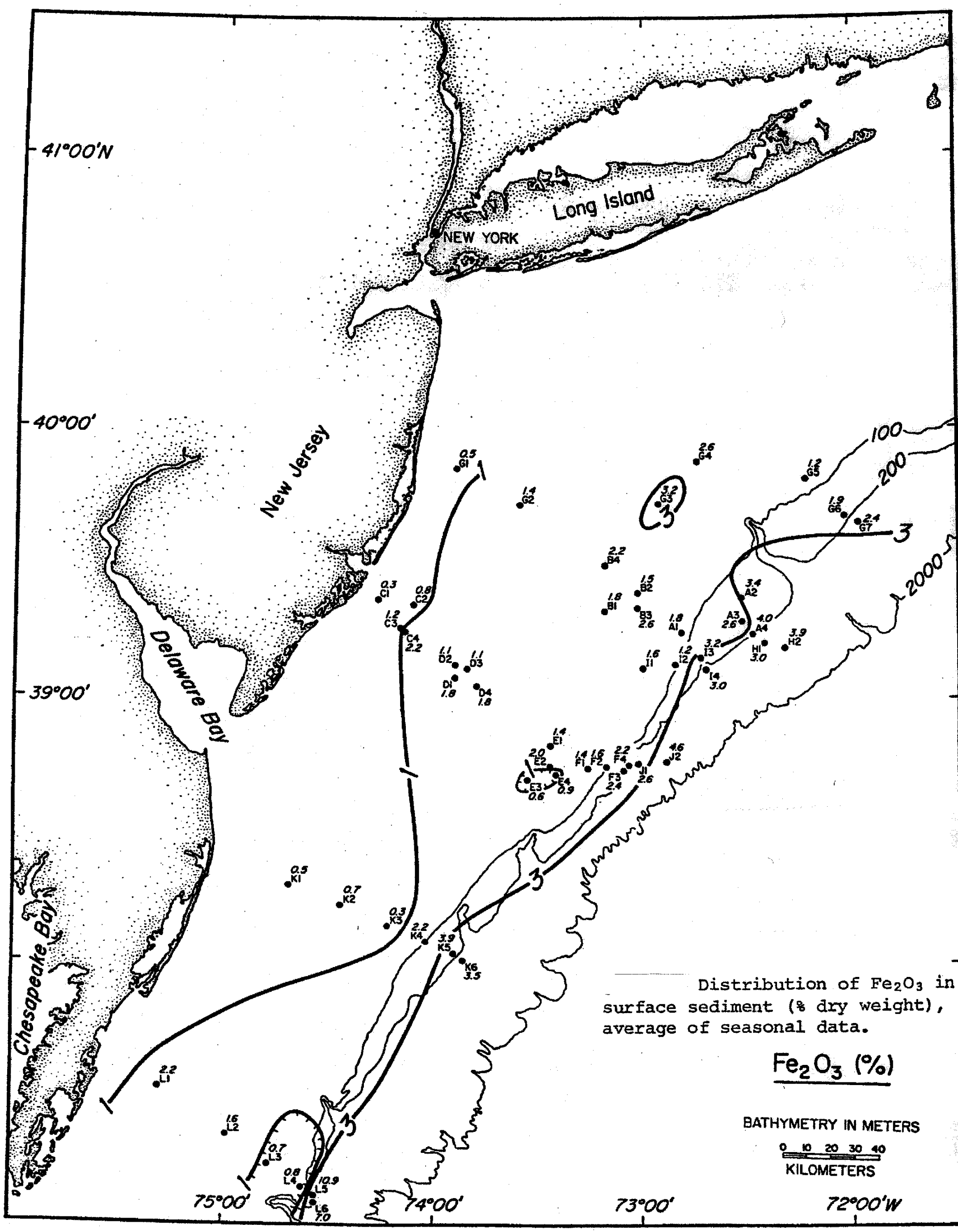
6.9 Archaeological/Cultural Resources

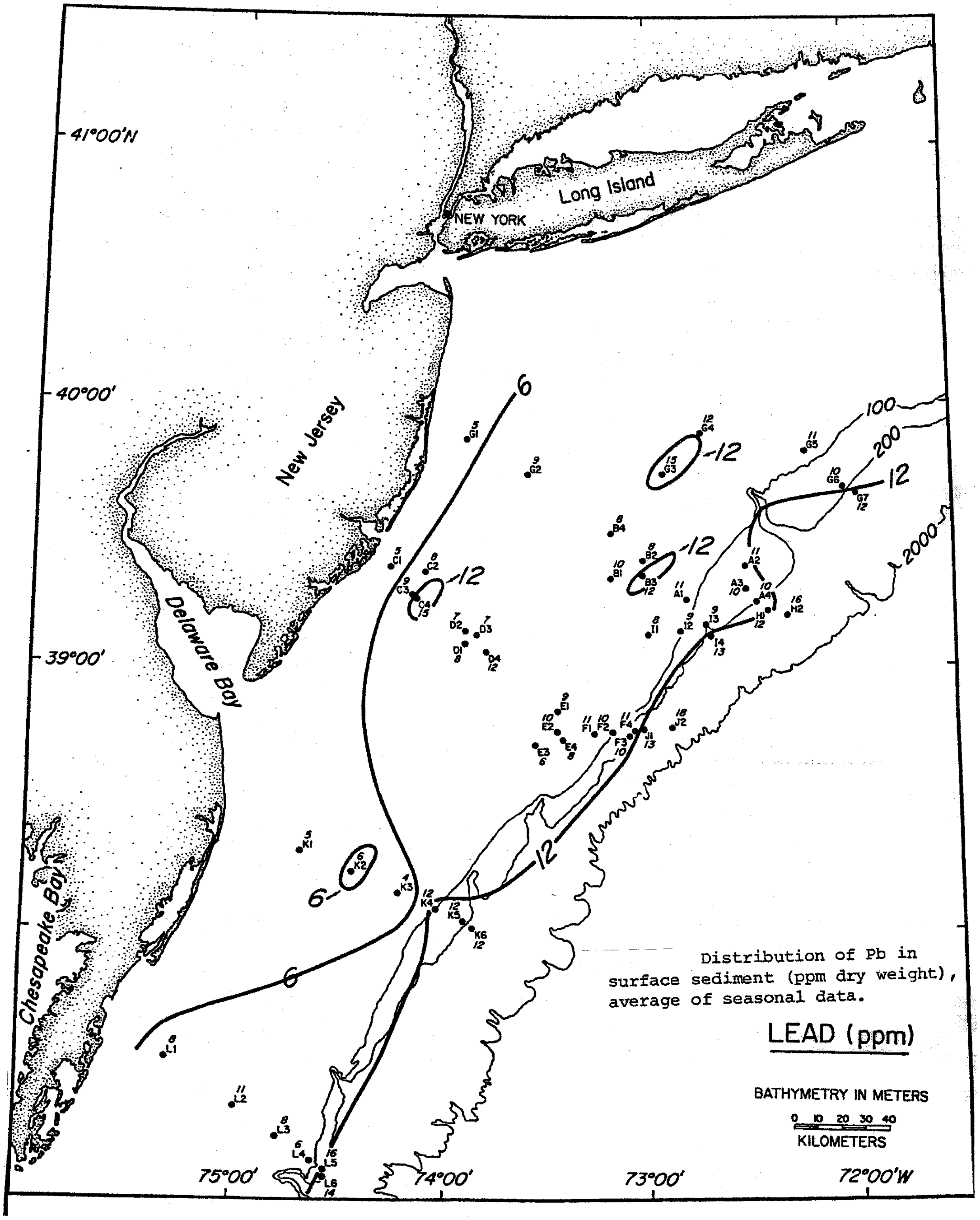
If Phase I (literature review) archaeological assessment for a proposed aggregate mining area indicates the potential for historic or prehistoric archaeological resources to occur within the area (*e.g.*, Figure 2-80), a remote sensing (Phase II) survey would be required to evaluate the potential aggregate source areas. If review of the remote sensing data and existing geologic core data indicate evidence of possible archaeological resources, the areas of these possible resources should be either investigated further (Phase III) to determine whether a resource actually exists at the location, and if so, it's identity and significance, or avoided by a distance sufficient to ensure protection of the possible resource. Coordination under Section 106 with the appropriate SHPO should be undertaken as required.

7.0 References

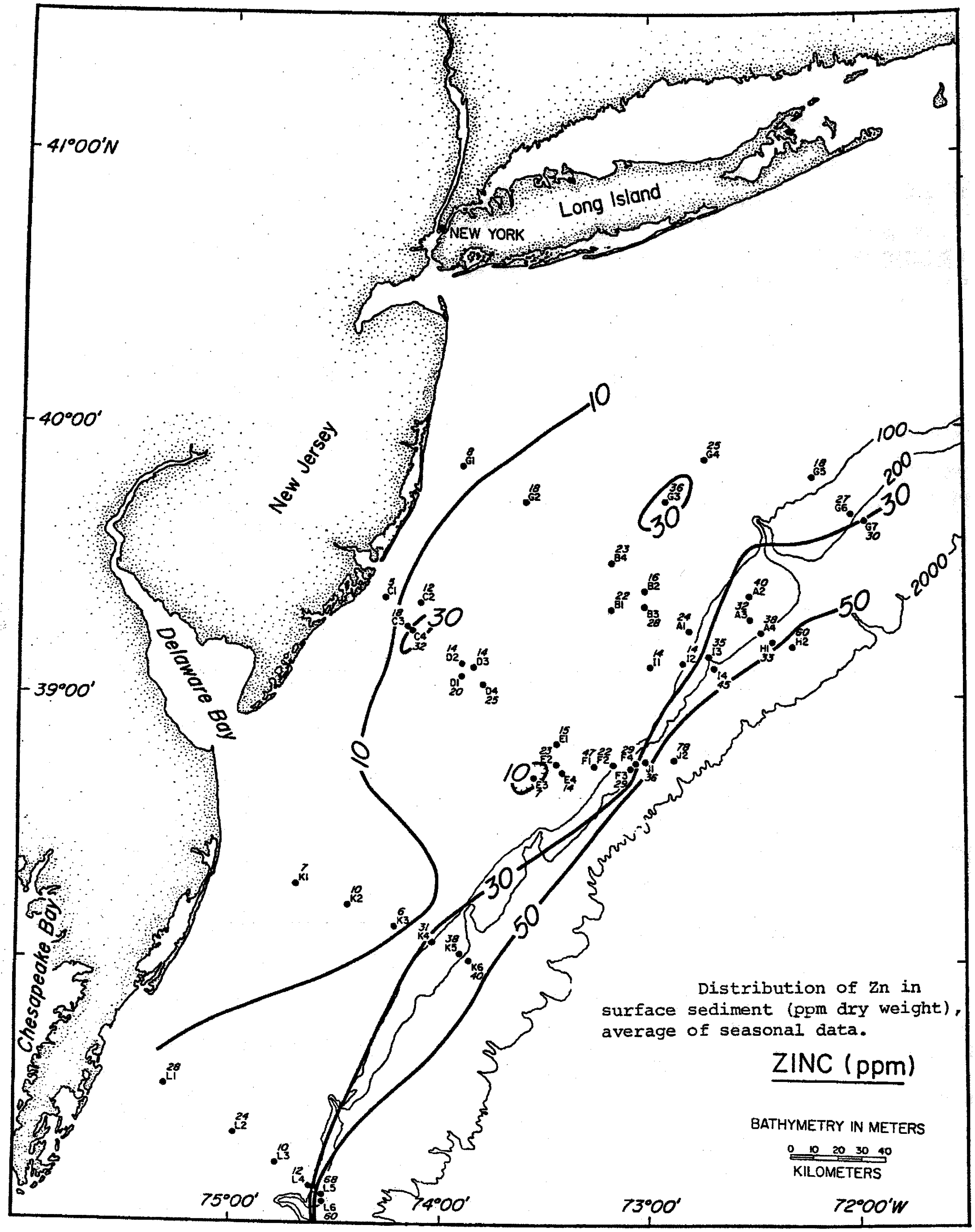
References for Appendix A are incorporated into the Chapter 6.0 (References) of the main body of the report.

APPENDIX B. CONCENTRATION OF METALS WITHIN OCS SEDIMENTS





Distribution of Pb in surface sediment (ppm dry weight), average of seasonal data.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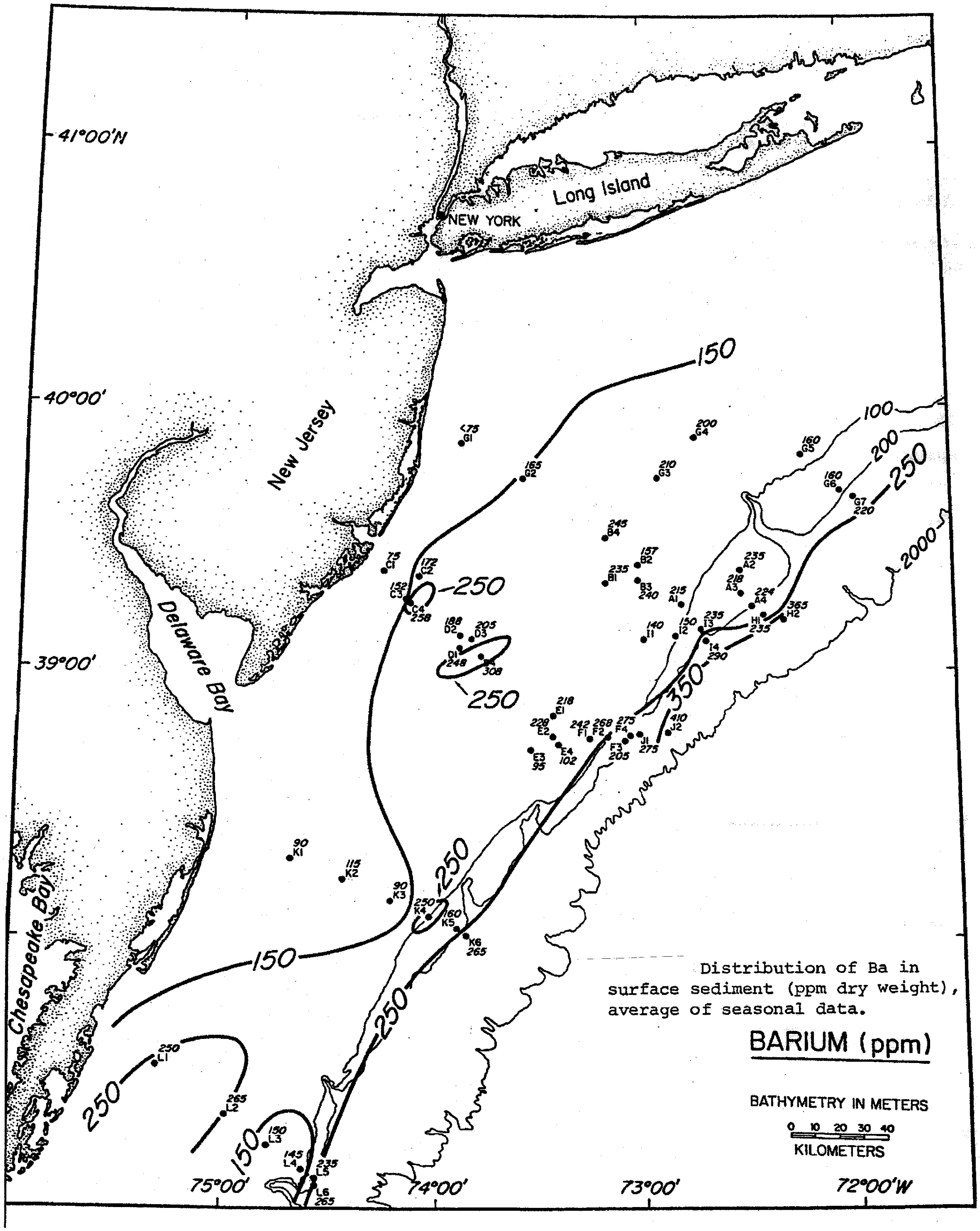
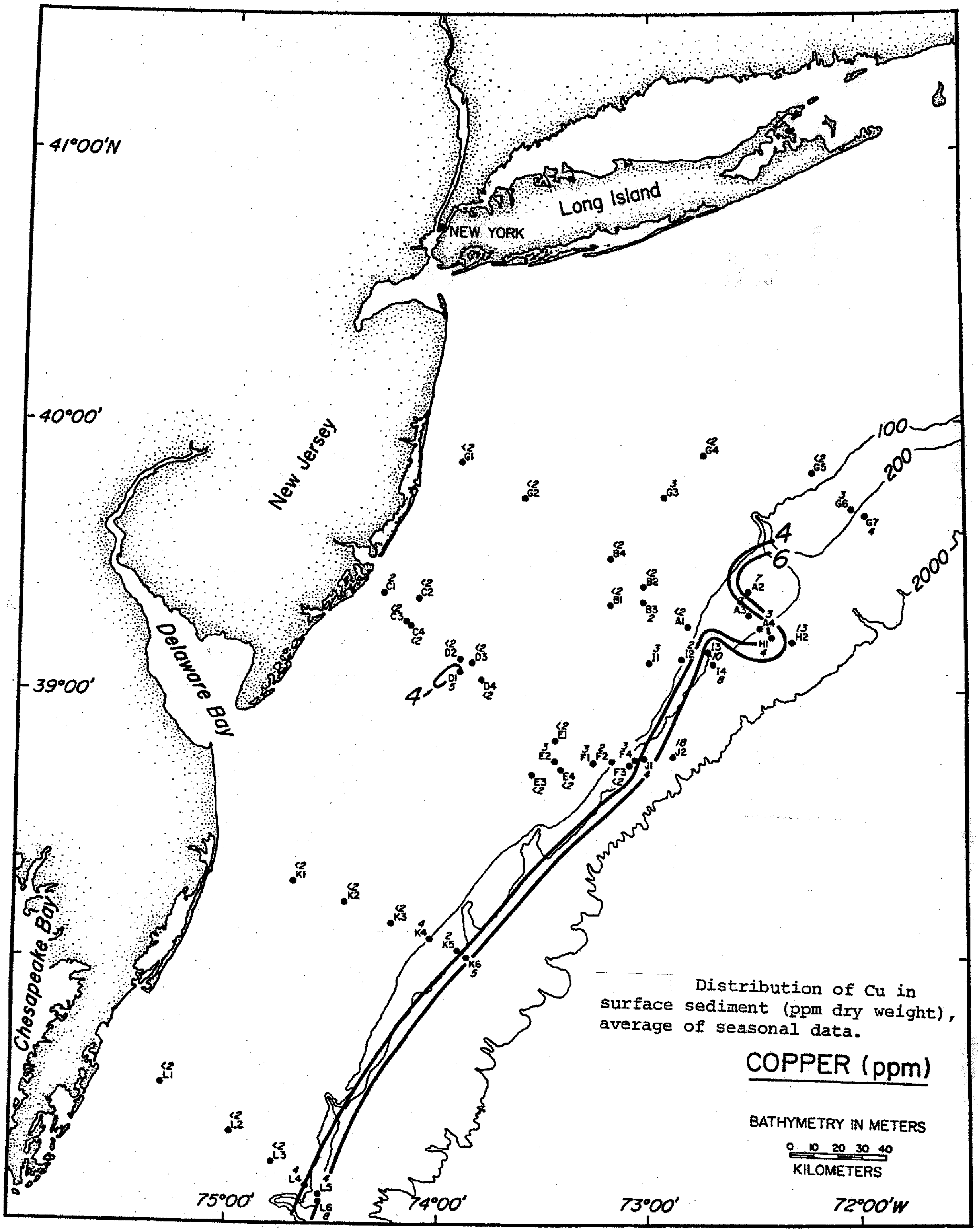
NEW YORK
Long Island
New Jersey
Delaware Bay
Chesapeake Bay
Distribution of Zn in surface sediment (ppm dry weight), average of seasonal data.
ZINC (ppm)
BATHYMETRY IN METERS
0 10 20 30 40
KILOMETERS



Distribution of Ba in surface sediment (ppm dry weight), average of seasonal data.


41°00'N
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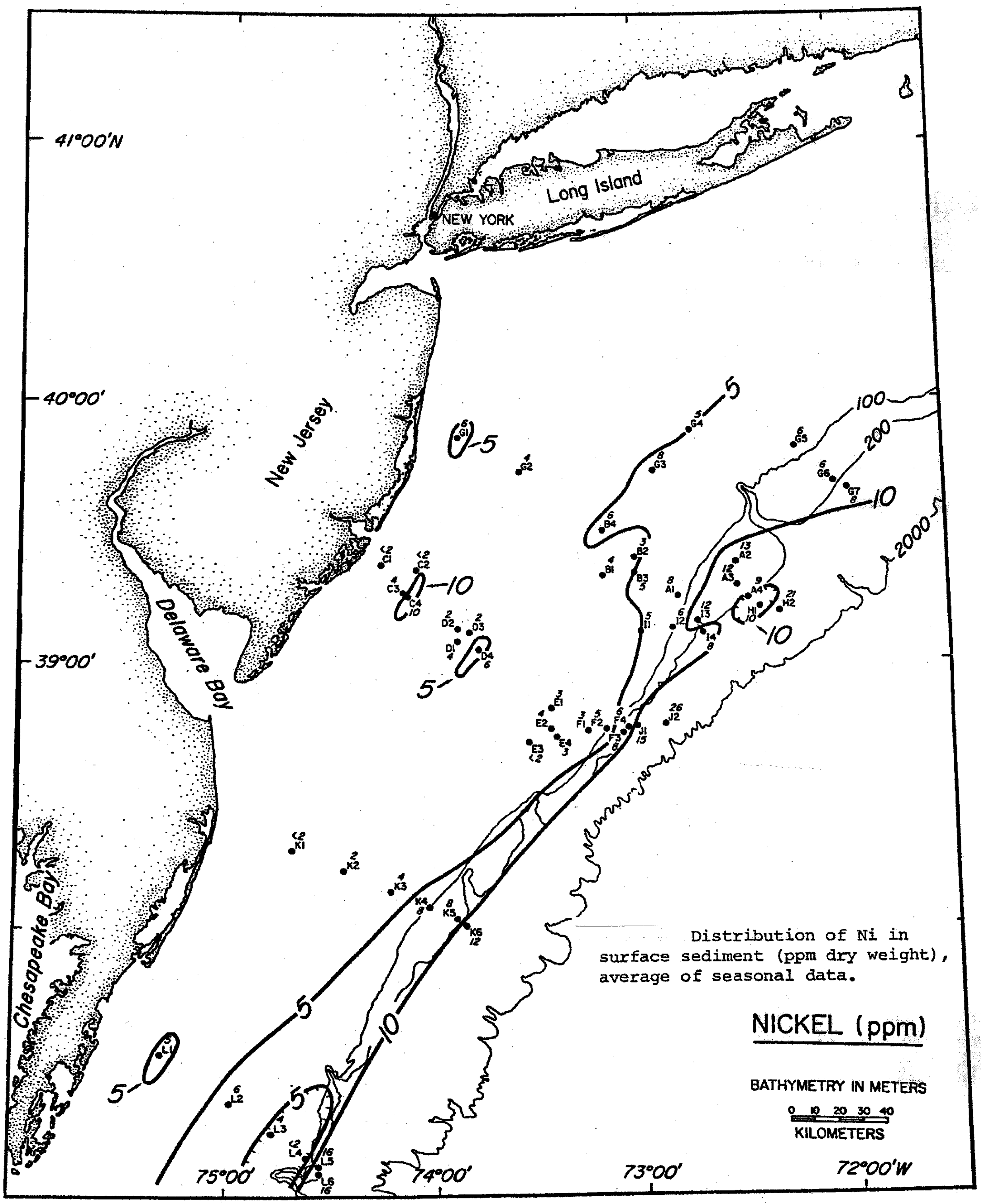
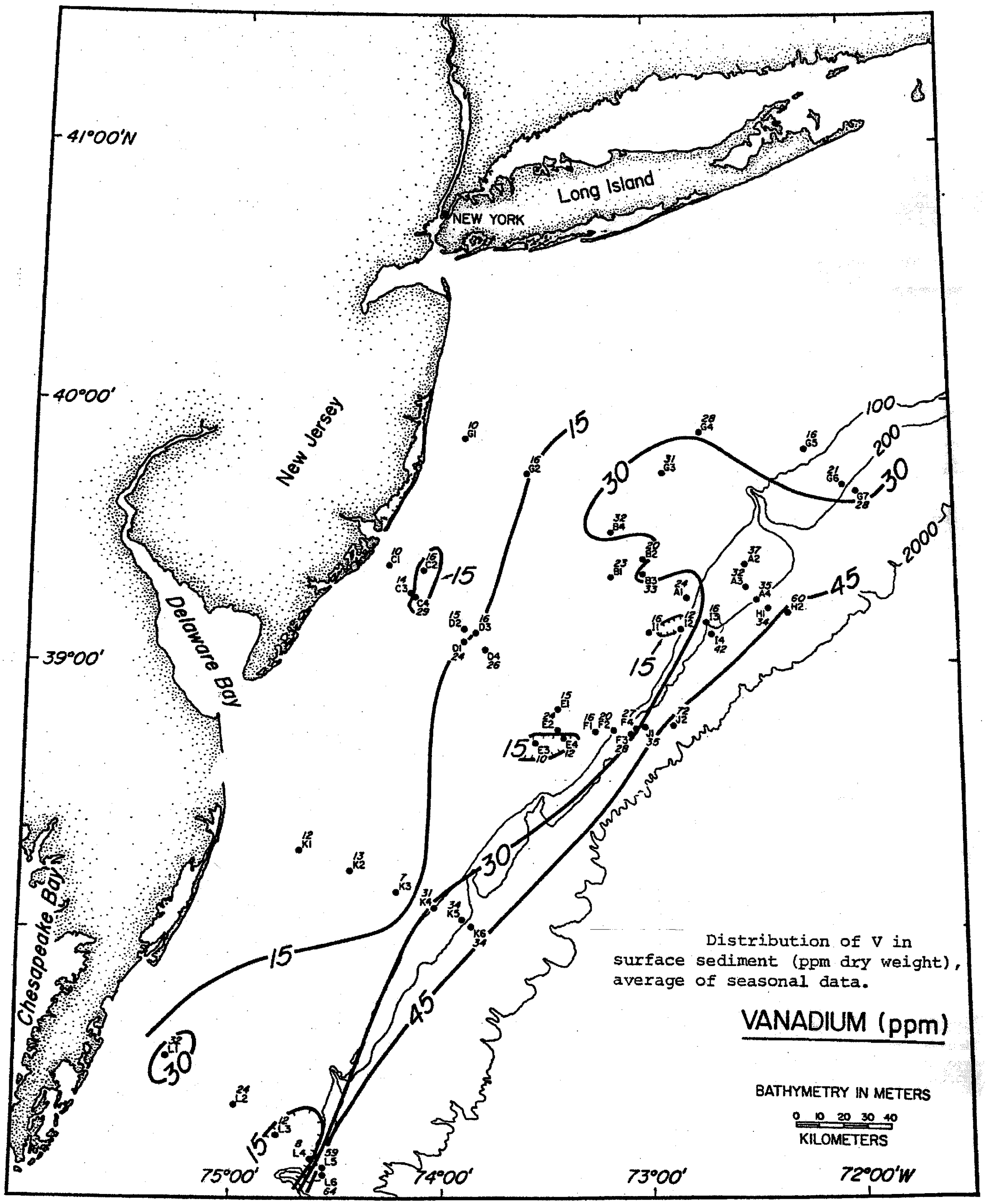
NEW YORK
Long Island
New Jersey
Delaware Bay
Chesapeake Bay
100
200
2000
Distribution of Cu in surface sediment (ppm dry weight), average of seasonal data.
COPPER (ppm)
BATHYMETRY IN METERS
0 10 20 30 40
KILOMETERS


41°00'N
40°00'
39°00'
75°00'
74°00'
73°00'
72°00'W
Long Island
NEW YORK
New Jersey
Delaware Bay
Chesapeake Bay
Distribution of Ni in surface sediment (ppm dry weight), average of seasonal data.
NICKEL (ppm)
BATHYMETRY IN METERS
0 10 20 30 40
KILOMETERS


41°00'N
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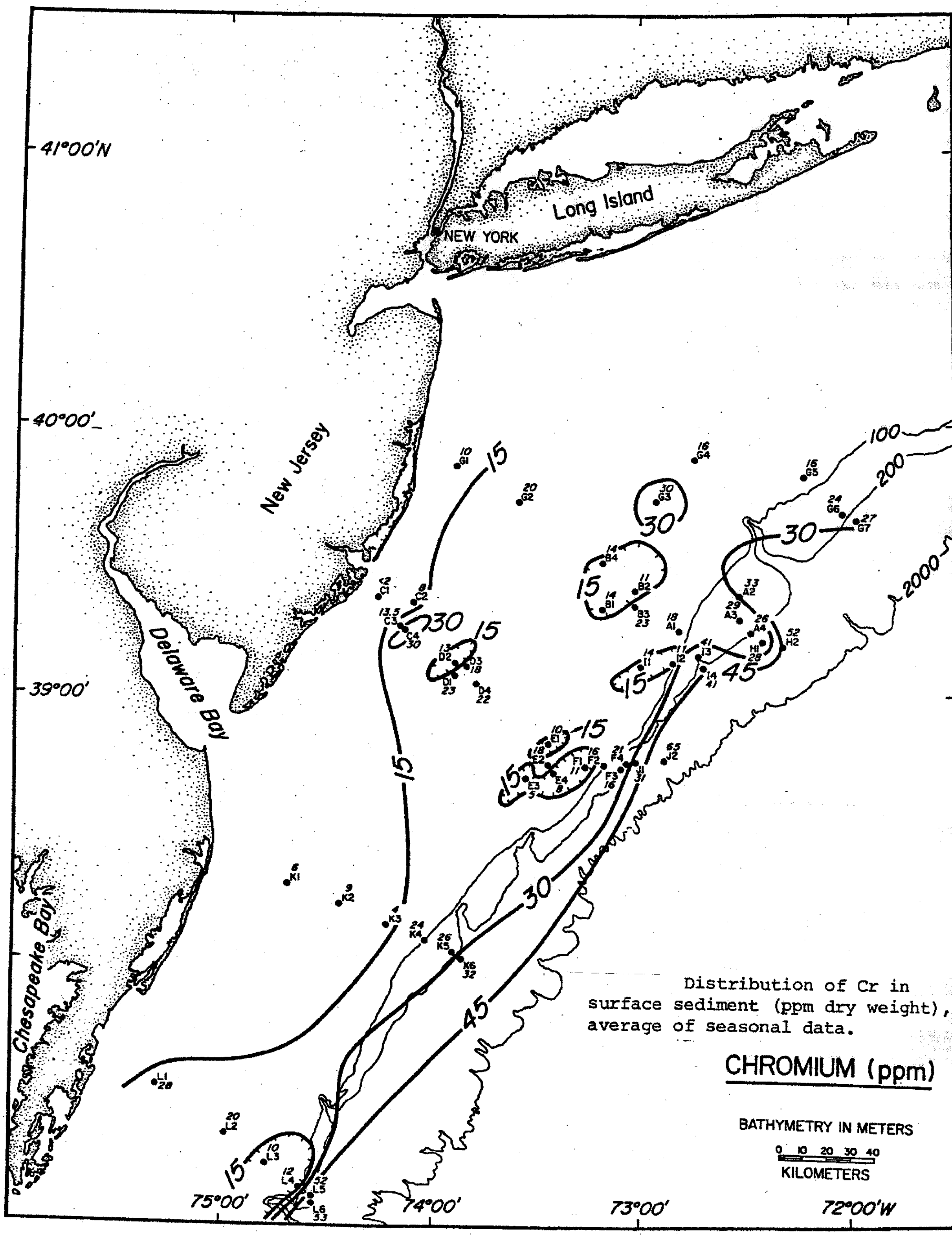
39°00'
Long Island
NEW YORK
New Jersey
Delaware Bay
Chesapeake Bay
75°00'
74°00'
73°00'
72°00'W
100
200
2000
Distribution of V in
surface sediment (ppm dry weight),
average of seasonal data.
VANADIUM (ppm)
BATHYMETRY IN METERS
0 10 20 30 40
KILOMETERS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74°00'
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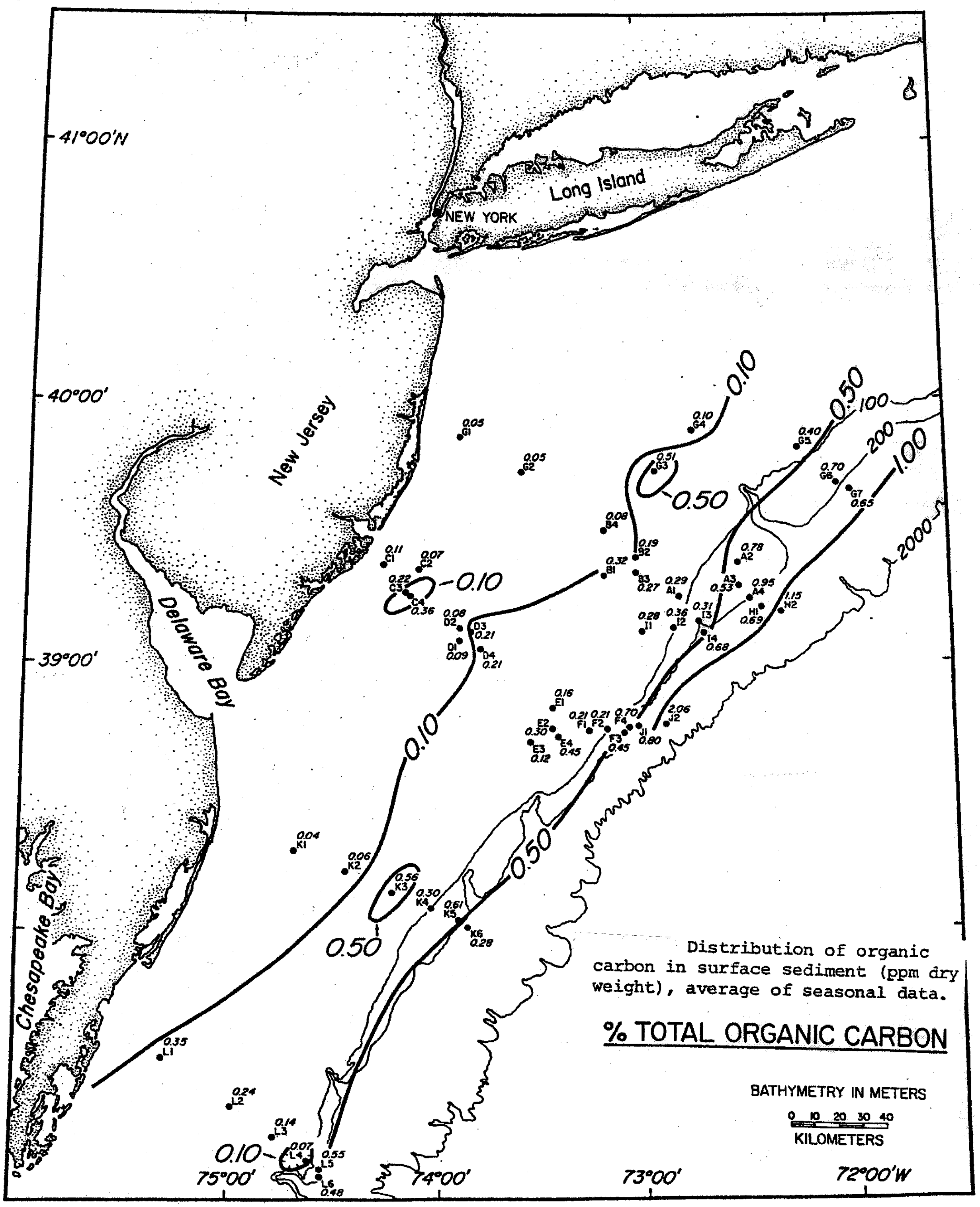
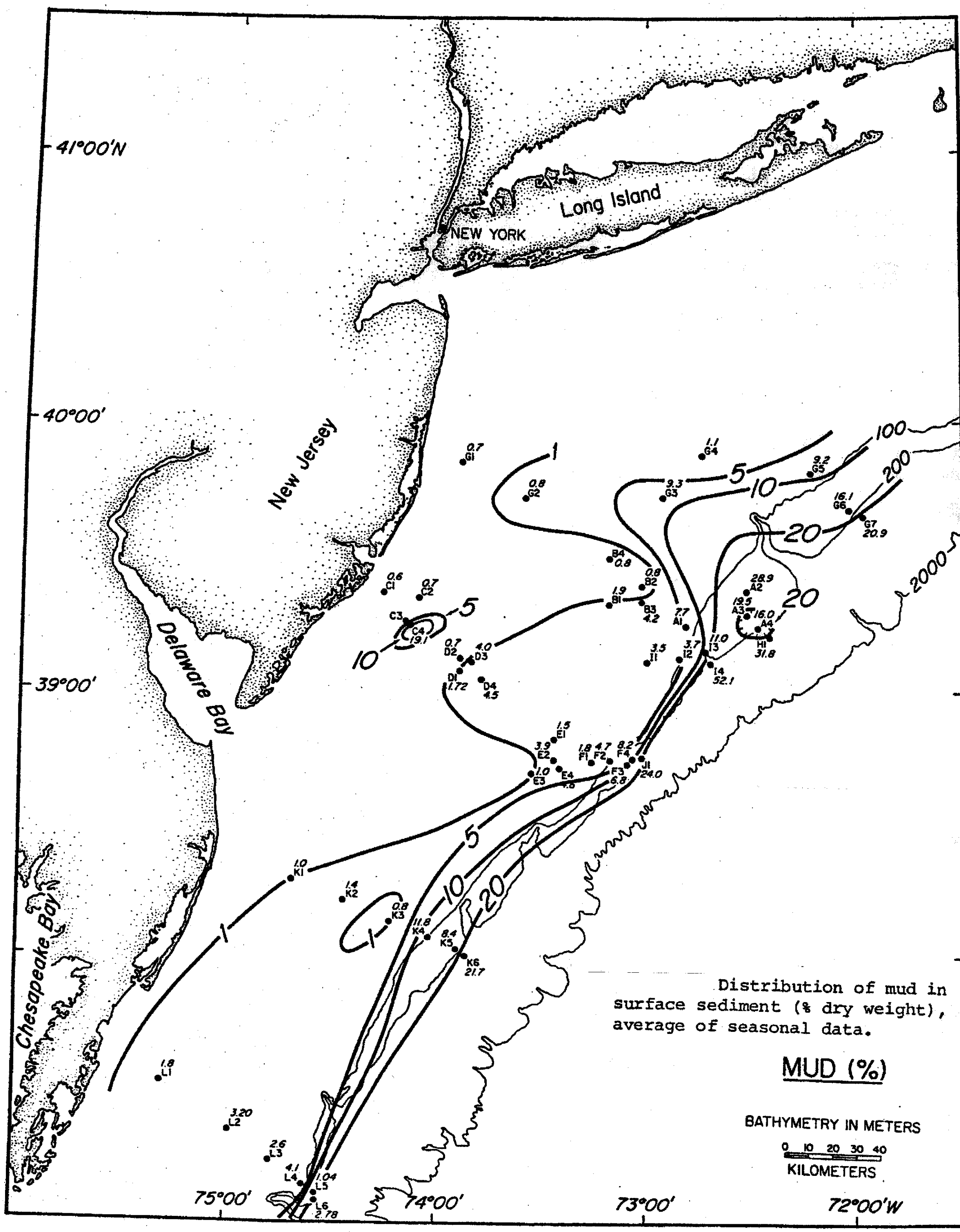
72°00'W
NEW YORK
Long Island
New Jersey
Delaware Bay
Chesapeake Bay
100
200
2000
Distribution of Cr in surface sediment (ppm dry weight), average of seasonal data.
CHROMIUM (ppm)
BATHYMETRY IN METERS
0 10 20 30 40
KILOMETERS

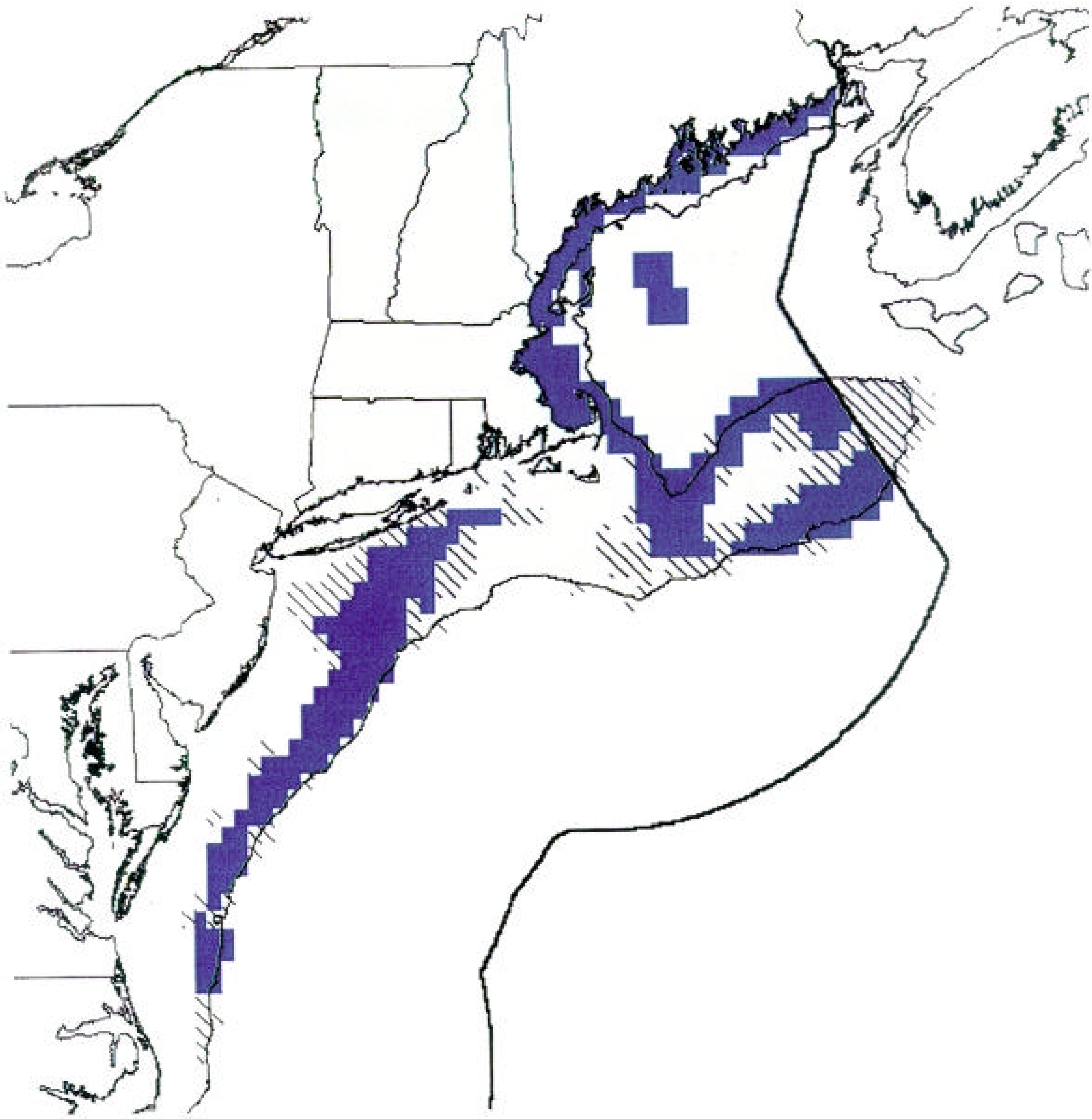


Distribution of organic carbon in surface sediment (ppm dry weight), average of seasonal data.

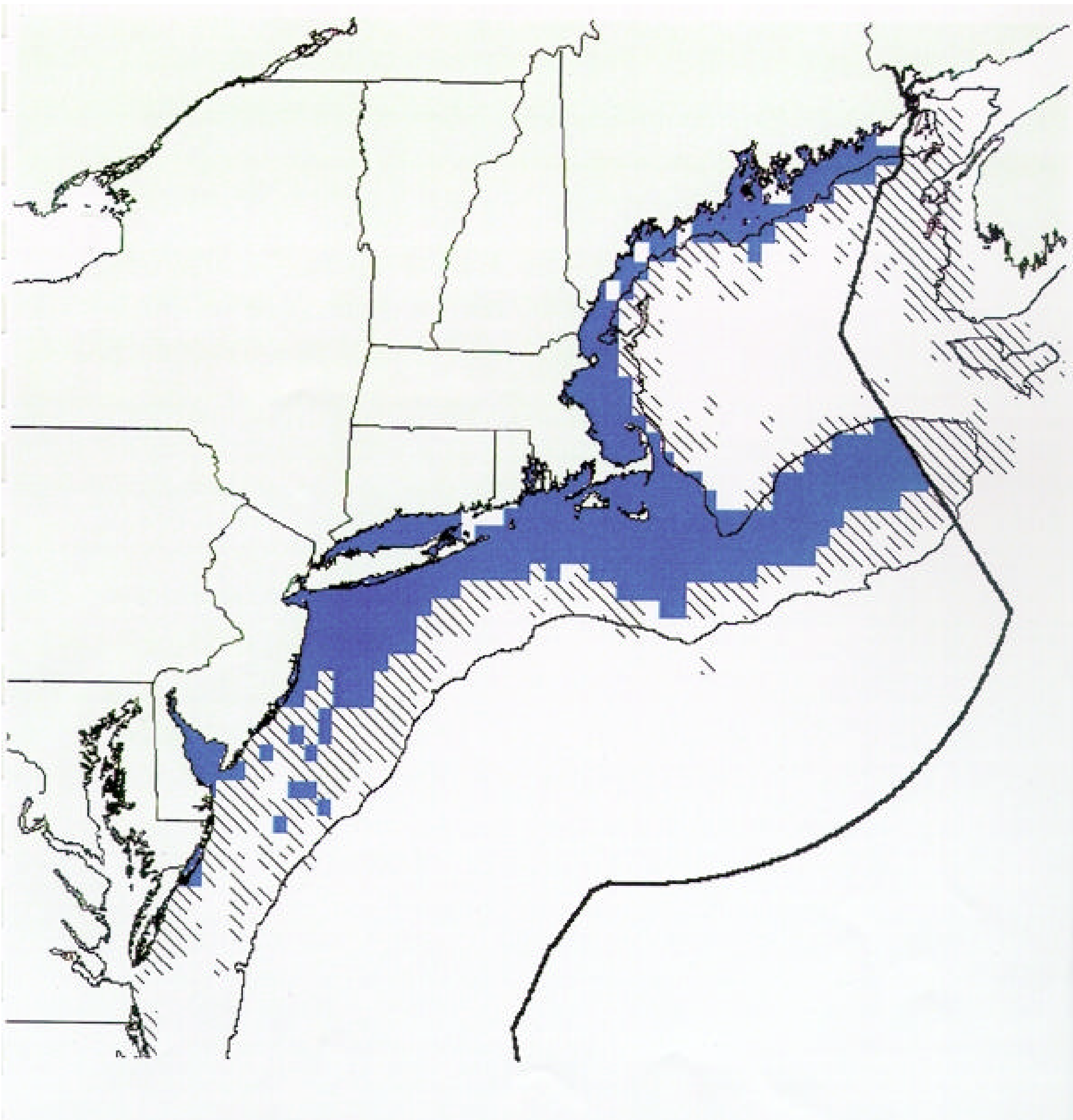


Distribution of mud in surface sediment (% dry weight), average of seasonal data.

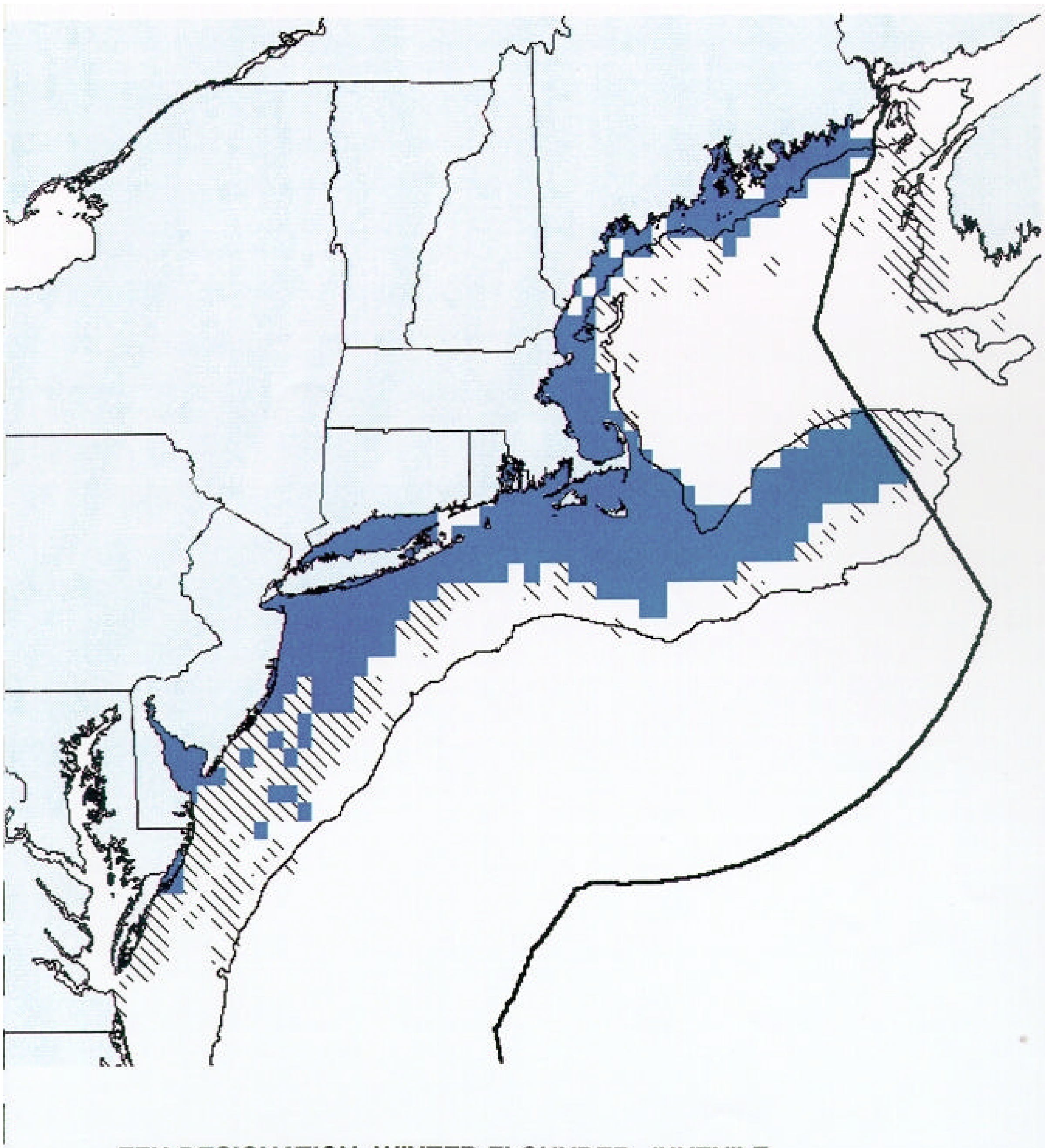
APPENDIX C. ESSENTIAL FISH HABITAT MAPS



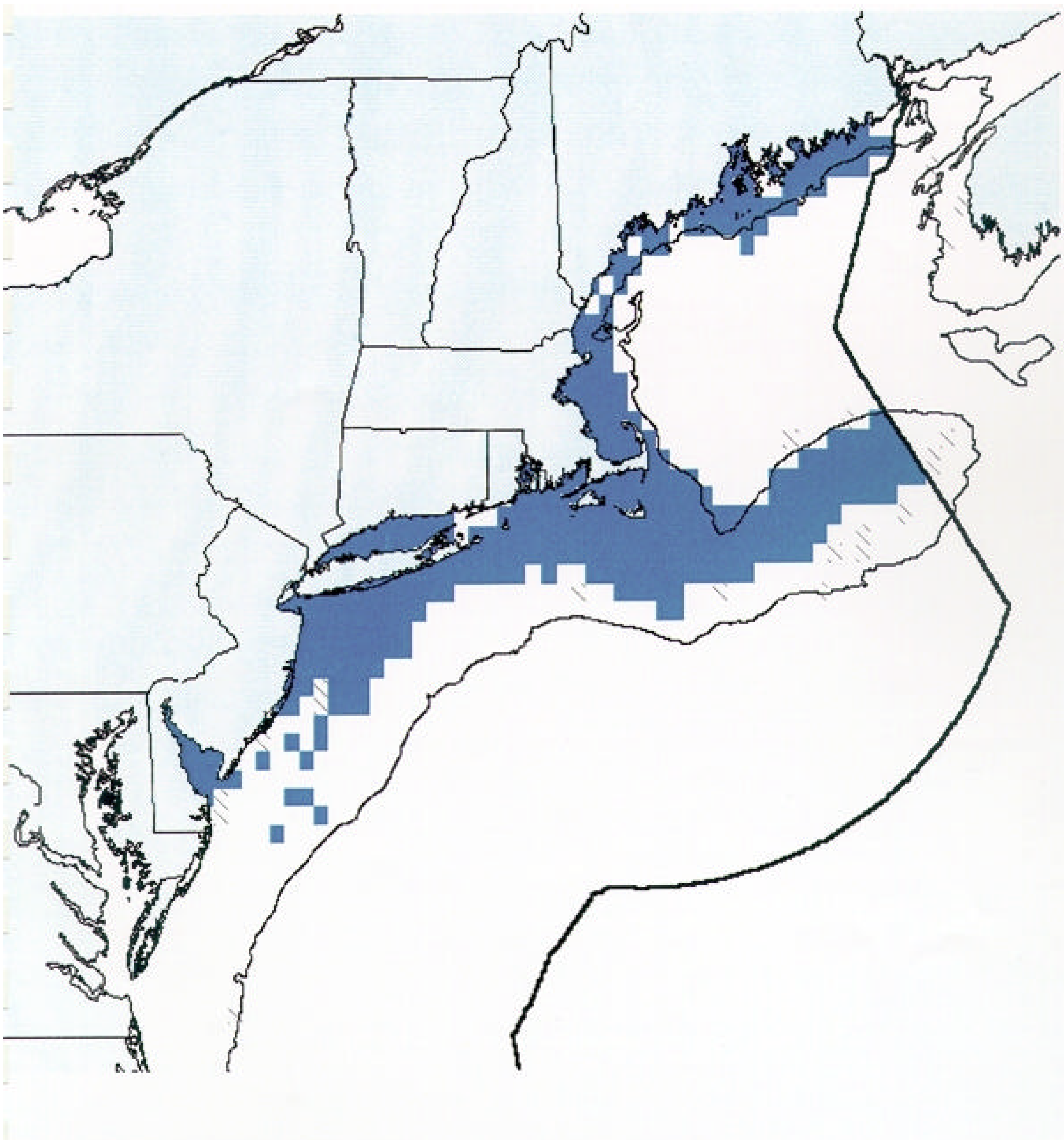
EFH DESIGNATION: SCALLOP



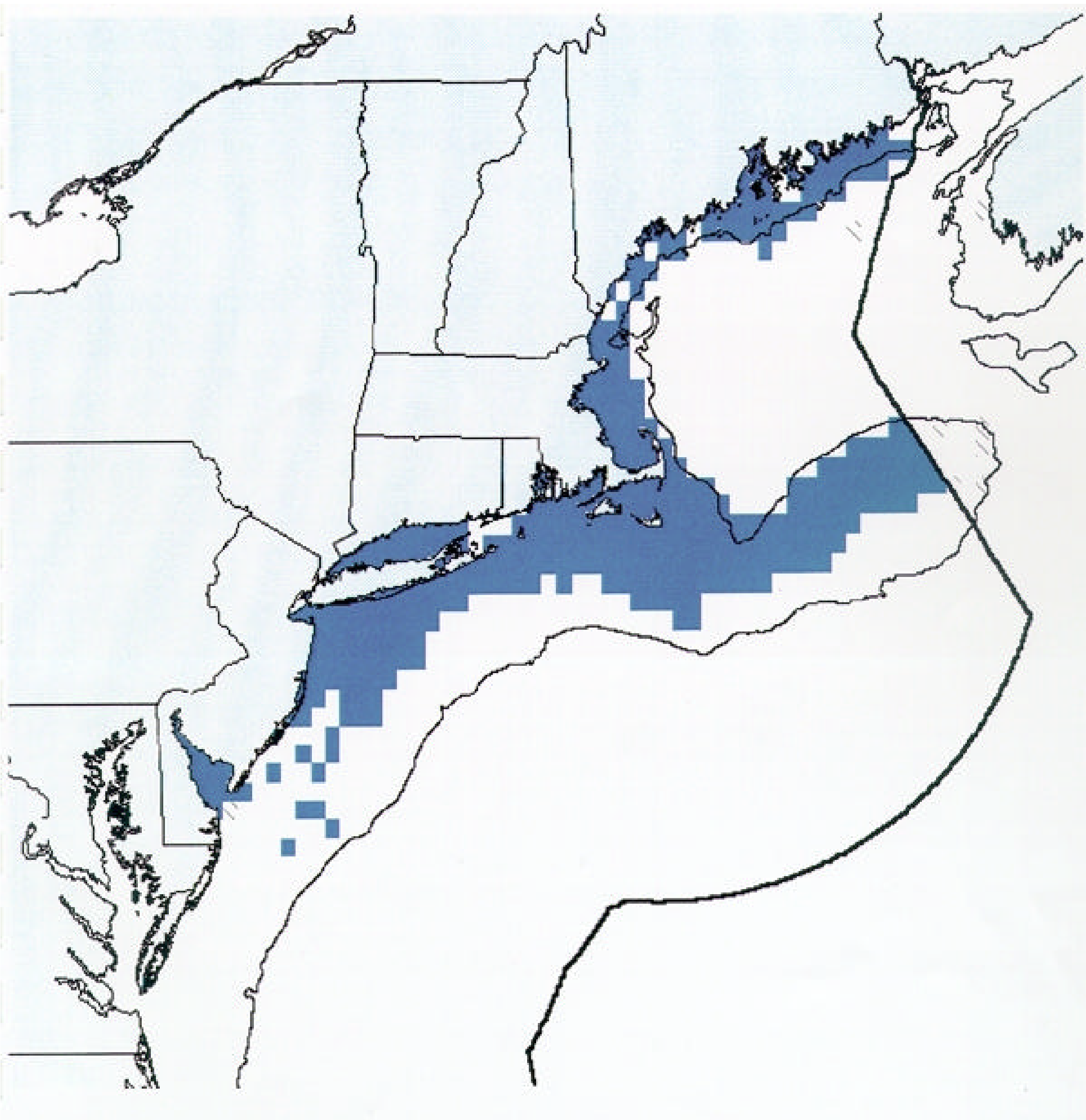
EFH DESIGNATION: WINTER FLOUNDER-ADULT



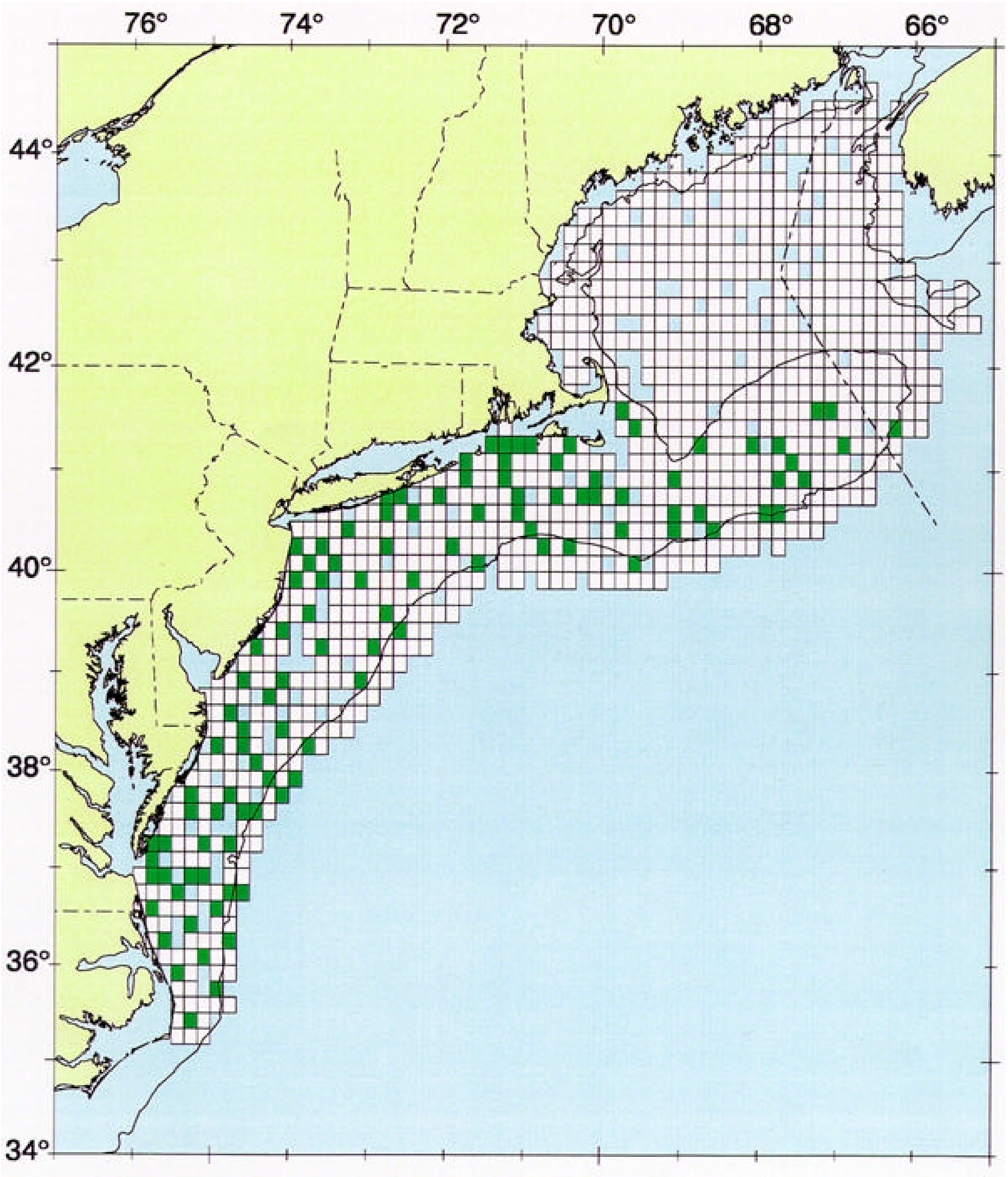
EFH DESIGNATION: WINTER FLOUNDER-JUVENILE



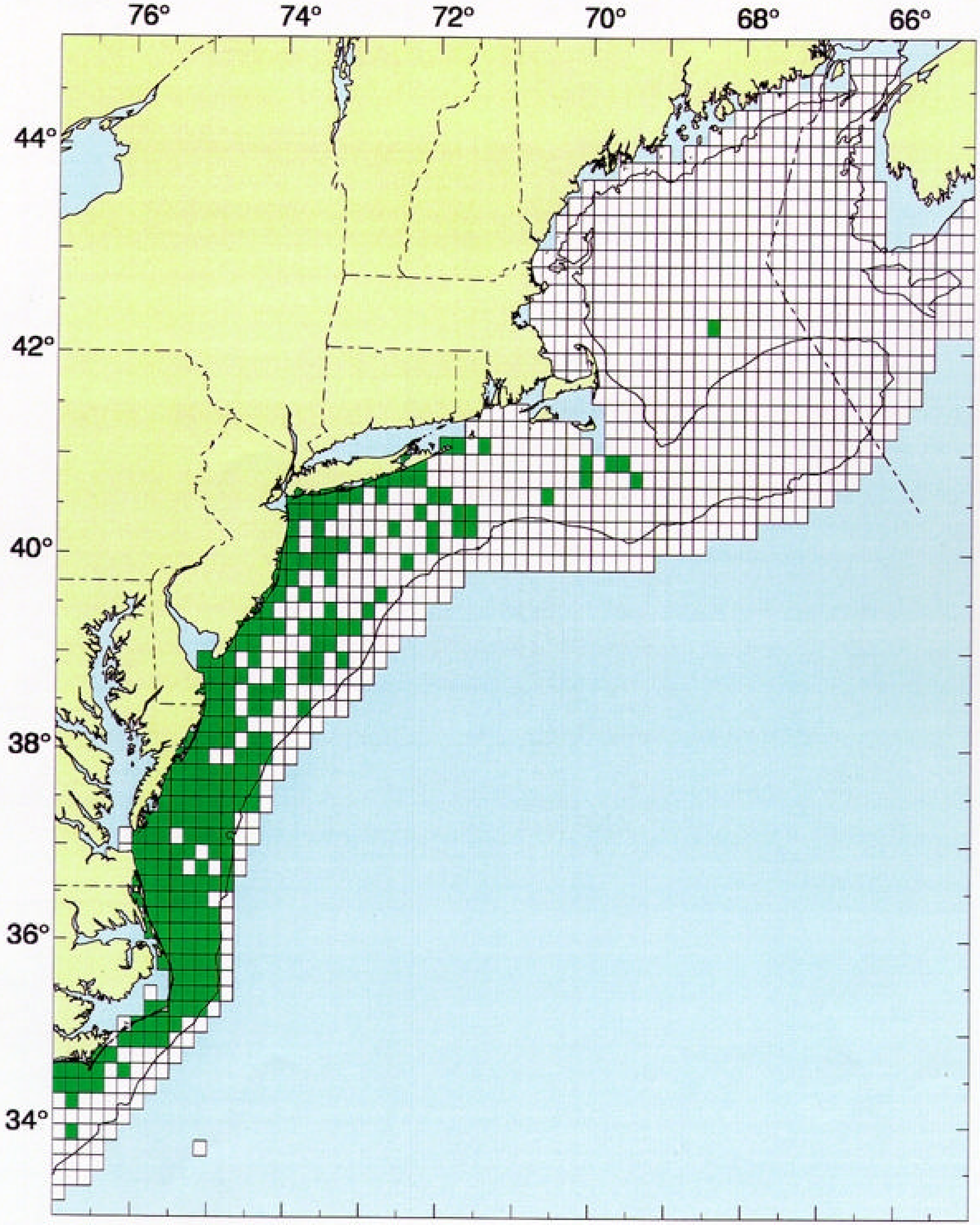
EFH DESIGNATION: WINTER FLOUNDER-LARVAE



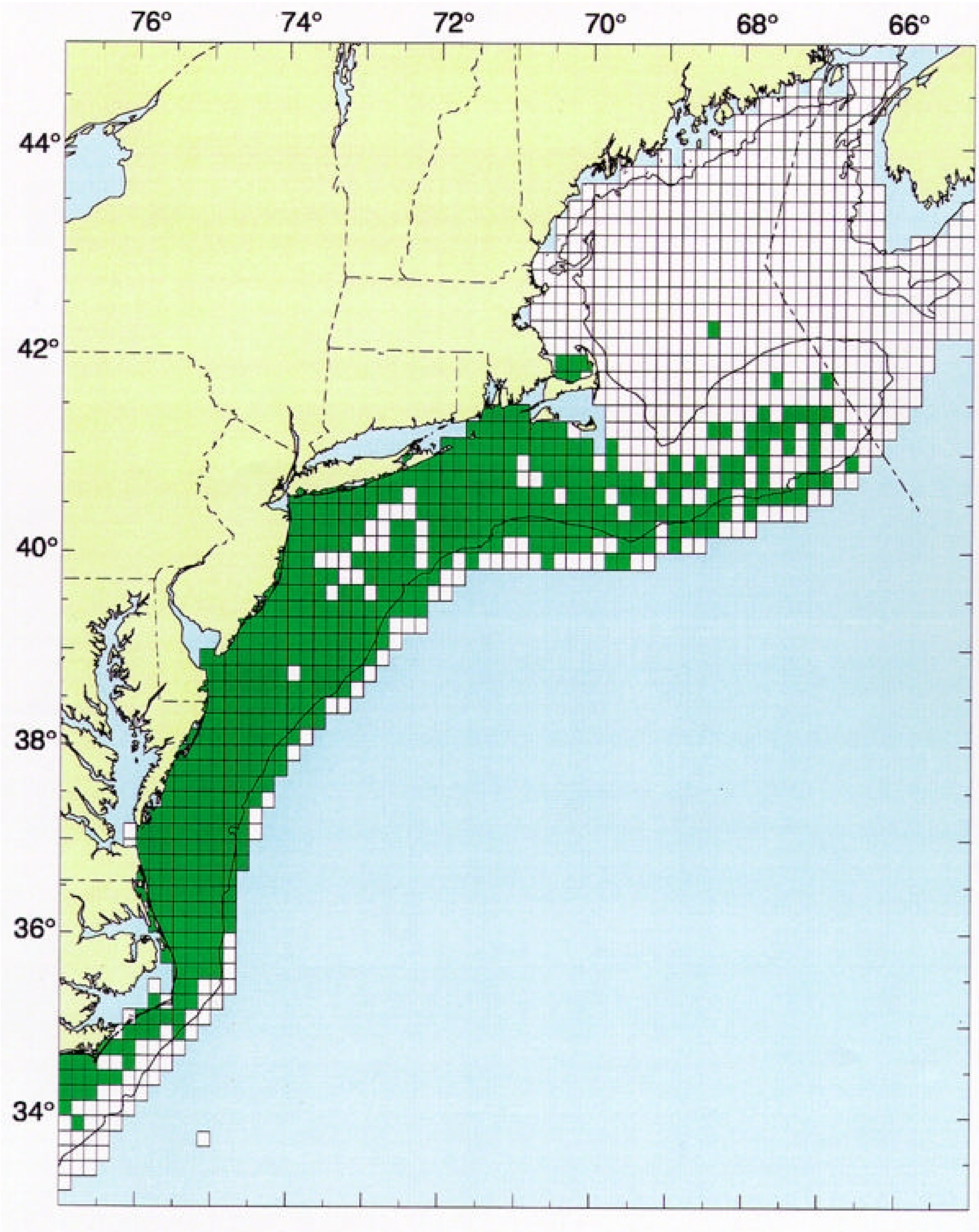
EFH DESIGNATION: WINTER FLOUNDER-EGGS



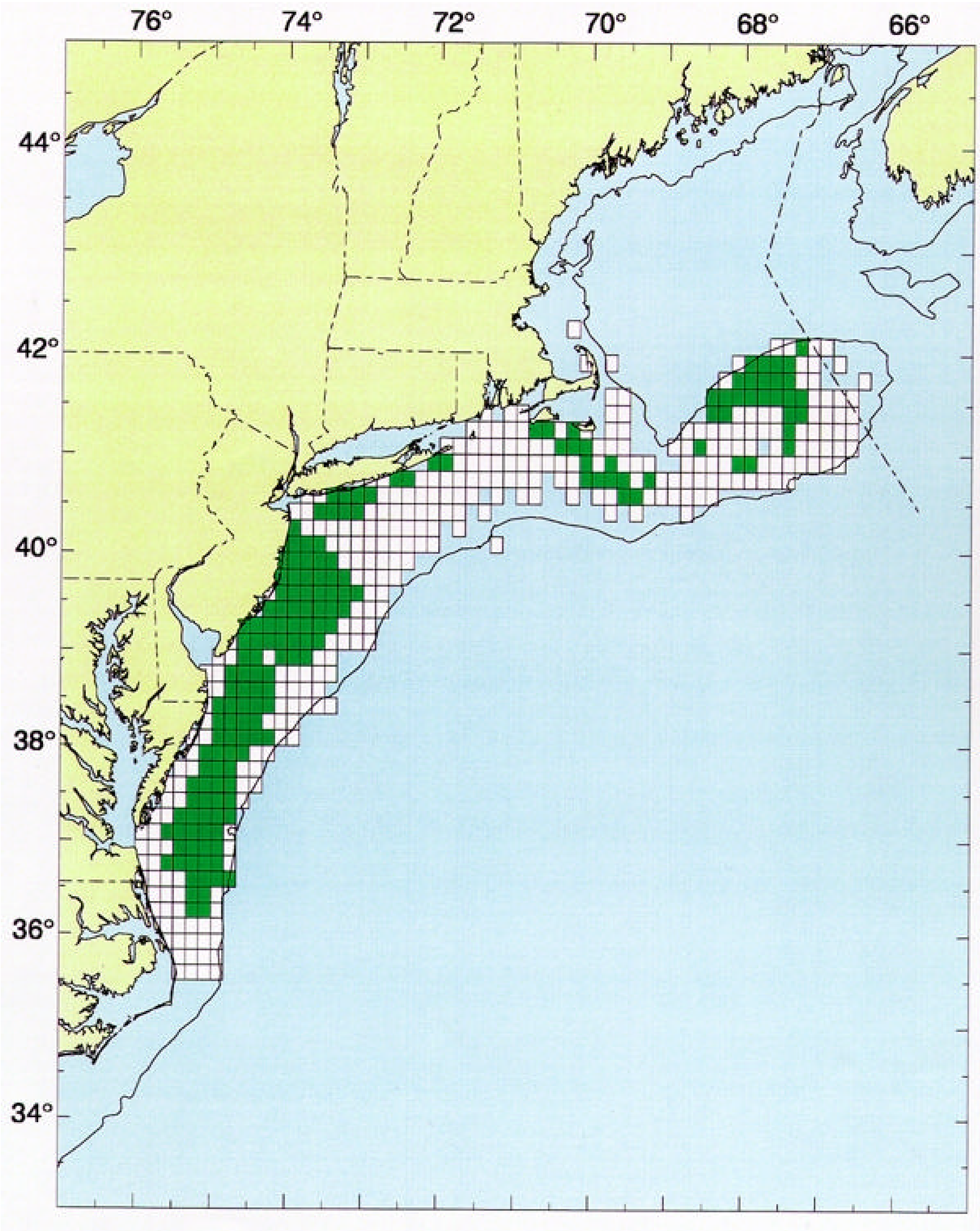
EFH Designation -- Summer Flounder -- Eggs



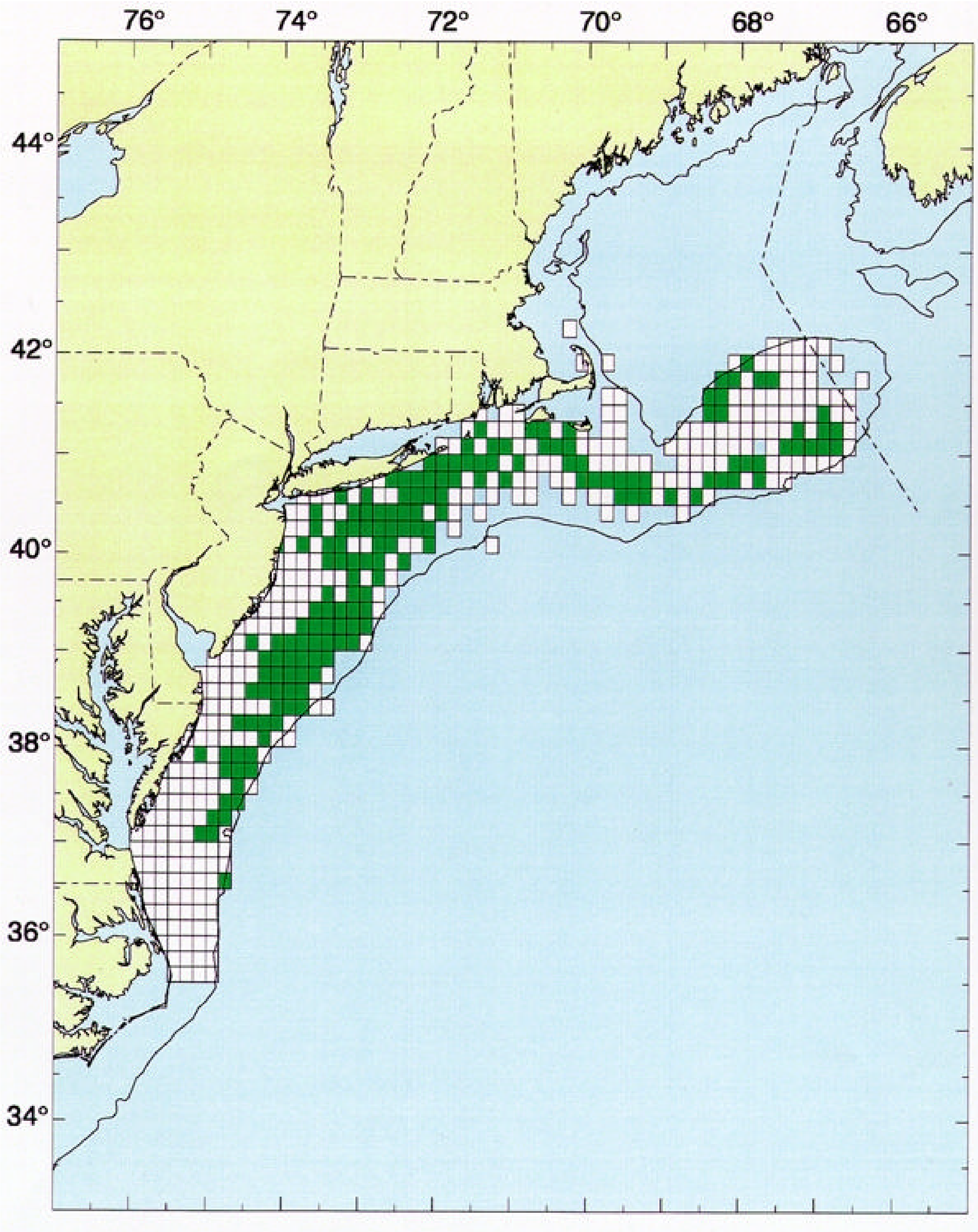
EFH Designation -- Summer Flounder -- Juveniles



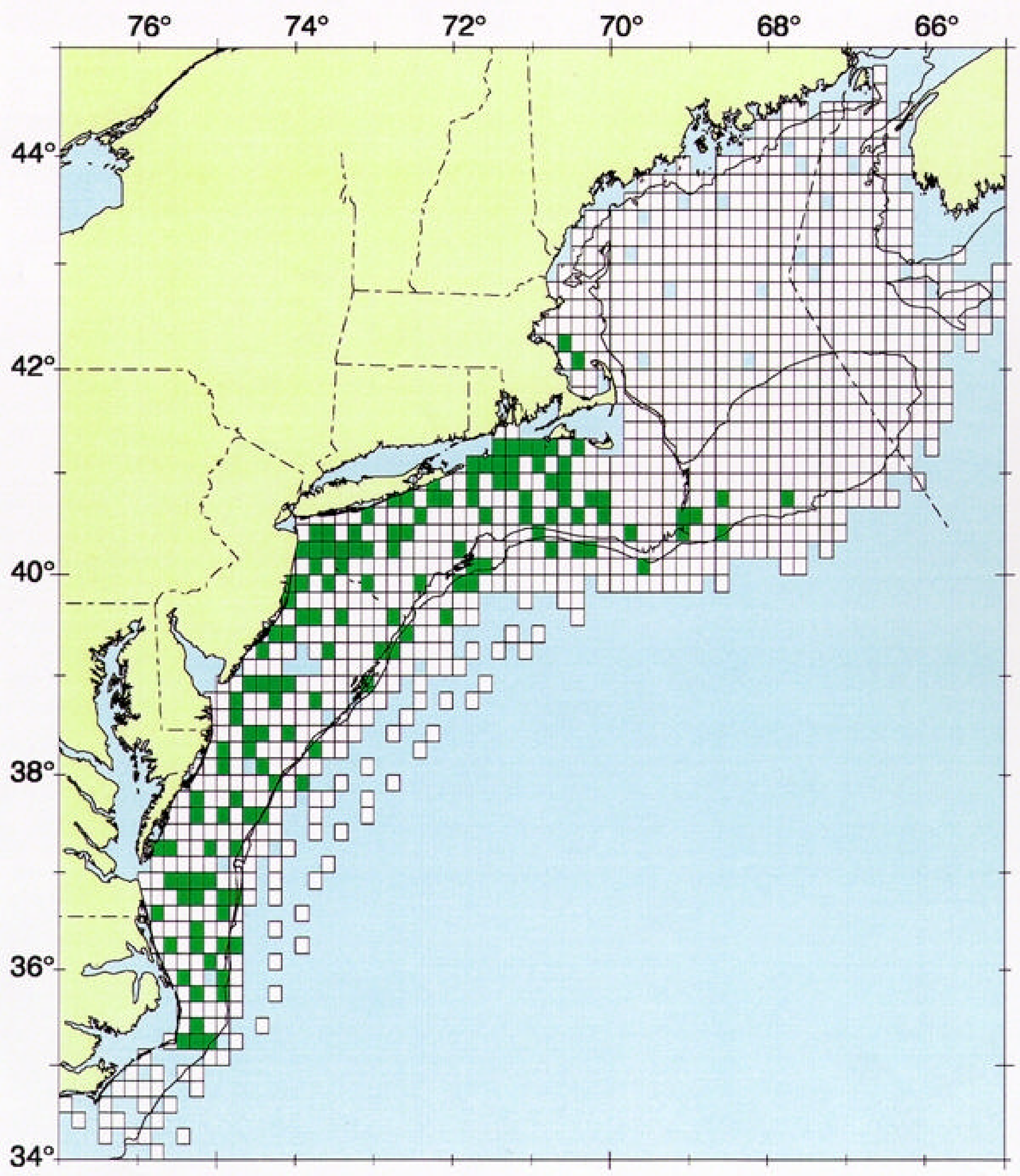
EFH Designation -- Summer Flounder -- Adults



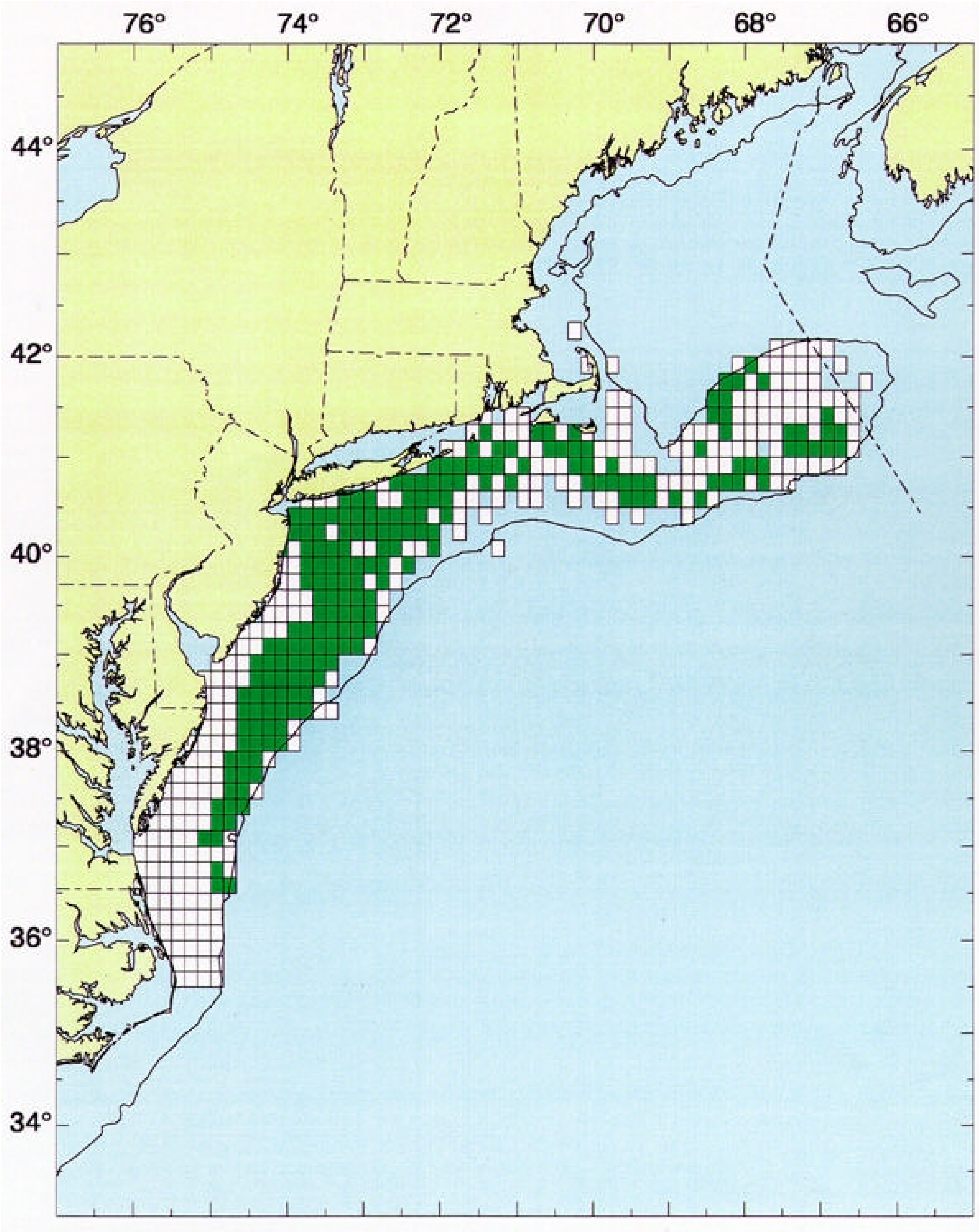
EFH Designation -- Atlantic Surfclam -- Recruits



EFH Designation -- Ocean Quahog -- Pre-recruits



EFH Designation -- Summer Flounder -- Larvae



EFH Designation -- Ocean Quahog -- Recruits

APPENDIX D. SUPPORTING CORRESPONDENCE

State of Delaware
DELAWARE GEOLOGICAL SURVEY
UNIVERSITY OF DELAWARE
Newark, Delaware
19716-7501

RECEIVED 4/26/99

ROBERT R. JORDAN, STATE GEOLOGIST
DELAWARE GEOLOGICAL SURVEY BUILDING
PHONE: 302-831-2833
FAX: 302-831-3579
E-MAIL: DGS@MVS.UDEL.EDU

April 23, 1999

Thomas R. Kitsos
Acting Director
Minerals Management Service
U.S. Department of the Interior
1849 C. Street, NW
Washington, DE 20240

Dear Tom:

On January 21, 1998, I responded to a letter addressed to Governor Carper from Cynthia L. Quarterman in which she requested definitive information about Delaware's plans and needs for sand resources from the Outer Continental Shelf off Delaware. At that time we were working with a sister agency, the Delaware Department of Natural Resources and Environmental Control, to refine estimates of existing and future sand resource needs to support shoreline protection projects.

The State of Delaware and the U.S. Army Corps of Engineers have developed an estimate of sand needs to accomplish replenishment work for the 50 year duration of proposed federal beach protection projects. The anticipated total for Delaware's oceanfront nourishment over the next 50 years is estimated to be about 23 million cubic yards. The Corps has identified borrow sources within the three-mile limit that may satisfy this need. The DGS through cooperative projects with the U.S. Minerals Management Service has identified several potential source areas beyond the three-mile limit. We are currently evaluating the sediment characteristics of the material and will be establishing potential volumes of sands that meet the specifications for beach nourishment material.

It is apparent to us that sand resources identified within the three-mile limit may not be adequate to meet anticipated demands for a number of reasons: (1) In recent months the question of essential fish habitat in the proposed borrow areas within the three-mile limit has been raised. Excavation farther from the shoreline may prove to have less of an adverse impact on essential fish habitats than those areas identified closer to shore; (2) Beach replenishment last summer in the Bethany Beach area resulted in the dredging up and inadvertent placement of unexploded ordnance onto the beach. The shells found are believed to be from land-based target shooting in support of military training operations. The Corps is currently conducting a relatively expensive investigation to locate ordnance on several beaches and in the surf zone. Accordingly, several

April 23, 1999
Page 2

sections of Delaware Atlantic Coast beaches will be closed for up to several months. Sand sources closer to shore are more likely to contain unexploded ordnance than resources farther from shore; (3) The calculated estimates of sand resource needs are based on our experience with beach nourishment over the past ten years as well as application of predictive models to determine the longevity of sand placed on the beach through nourishment activities. If the estimates are low or if catastrophic storm events result in additional sand needs, then sand resources in federal waters may be required to meet demands; (4) Long-term performance of sand on beaches is generally proportional to sediment characteristics such as grain size, coefficient of sorting, mineralogy, etc. Sand resources beyond the three-mile limit may have more suitable characteristics for beach nourishment than near shore material.

We have enjoyed an excellent working relationship with the MMS as well as with our colleagues in Maryland. Our contractual partnerships have been very productive and mutually beneficial, and we are looking forward to continuing our work with the MMS on investigations that are important to Delawareans as well as to the citizens of the United States.

Sincerely,

Robert R. Jordan
Director and State Geologist

cc: Roger Amato
John Talley

RRJ: ms

COMMONWEALTH *of* VIRGINIA

Office of the Governor

James S. Gilmore, III
Governor

John Paul Woodley, Jr.
Secretary of Natural Resources

January 29. 1999

Ms. Cynthia Quarterman, Director
Minerals Management Service
United States Department of the Interior
Washington, D. C. 20240

Dear Ms. Quarterman:

Governor Gilmore has asked me to respond to your letter soliciting the Commonwealth's perspective and plans concerning the direction of future cooperative work with the Minerals Management Service (MMS) of the Department of the Interior regarding the identification of sand resources in federal waters off the coast of Virginia. As you stated in your letter, the Commonwealth, through the Virginia Institute of Marine Science and the Department of Conservation and Recreation, has worked with MMS to successfully identify sand resources that may be suitable for beach nourishment. Based on the success of our past efforts, the Commonwealth is willing to continue to work with MMS to identify additional sand resources.

The Commonwealth is blessed with beautiful beaches, which provide recreational benefits to its citizens, economic benefits through tourism and storm damage protection. Yearly maintenance and future enhancement projects are planned for approximately 24.5 miles of public beach in the Cities of Hampton, Norfolk and Virginia Beach. Therefore, the identification of offshore sand resources suitable for beach nourishment for all three cities is and should be a priority for future cooperative efforts between MMS and the Commonwealth.

The development of a cooperative workplan between MMS and the Commonwealth is needed to further refine the search for potential offshore sand resources. For assistance in the development of the workplan, please contact Lee Hill of the Department of Conservation and Recreation at (804) 786-3998.

P.O. Box 1475 • Richmond. Virginia 23218 • (804) 786-0044 • TDD (804) 786-7765

Ms. Cynthia Quarterman, Director
January 29, 1999
Page Two

I believe the identification of potential offshore sand resources is critical to the future of the Commonwealth's public beaches.

Very truly yours,

John Paul Woodley, Jr.

John Paul Woodley, Jr.

JPW/j

Cc: The Honorable David G. Brickley
Thomas M. Felvey
Dr. Stanley S. Johnson
Donald O. Campen, Jr.
Lee Hill, DCR

RECEIVED 5-17-99

State of New Jersey
Department of Environmental Protection
CN 402
Trenton, NJ 08625-0402

Christine Todd Whitman
Governor

Robert C. Shinn, Jr
Commissioner
Tel. # (609) 292-2885
Fax # (609) 292-7695

May 5, 1999

Ms. Cynthia Quarterman, Director
US Department of the Interior
Minerals Management Service
Washington, DC 20240

Dear Ms. Quarterman:

I am writing in response to your letter to Governor Christine Todd Whitman regarding the management of the sand and gravel resources located on the outer continental shelf. Please accept my apologies for the delay in responding to your request for information regarding our needs as it relates to offshore sand sources.

As you know, for many years now, the New Jersey Geological Survey Bureau has been working closely with members of the Minerals Management Service Organization investigating and identifying potential sand and gravel resources off the New Jersey shoreline. The department is interested in these offshore resources as a contingency to New Jersey's Shore Protection Program.

New Jersey's Shore Protection Program is a cooperative program between the state and the US Army Corps of Engineers, which began with the approval of the Water Resources Development Act of 1986. I have enclosed for your information a set of charts showing how the New Jersey shoreline has been divided into reaches. Each of these reaches can act independent and each reach has its own sand source that will last the life of the authorized federal project. All of the borrow sites for the shore protection projects are currently located within the three mile area. Some may overlap just beyond the three-mile limit.

Several years ago, the Department's Division of Engineering and Construction together with the Geological Survey Bureau began to investigate potential offshore sources of sand. All of these offshore sources were located in federal waters. Also enclosed is a map depicting the broad area of investigation and then the more narrow or site specific investigation. The incentive for the offshore investigation was to identify areas where sand would be available in the event of a major storm event along our shoreline that could be used for immediate restoration and repair. These offshore sources of sand would supplement existing inshore borrow sites that were or will be identified by the Army Corps. projects. To date, we have completed all of the necessary vibracore borings in areas A and G with continuing investigation in areas C and F. Environmental assessments have been completed in area A and are ongoing in area G.

New Jersey is (

Ms. Cynthia Quarterman
May 5, 1999
Page 2

It is extremely important to the state shore protection efforts that we continue to identify sources of sand in federal waters. New Jersey is committed to shore protection and the restoration and preservation of our beaches. These offshore sources of sand are vital to our program.

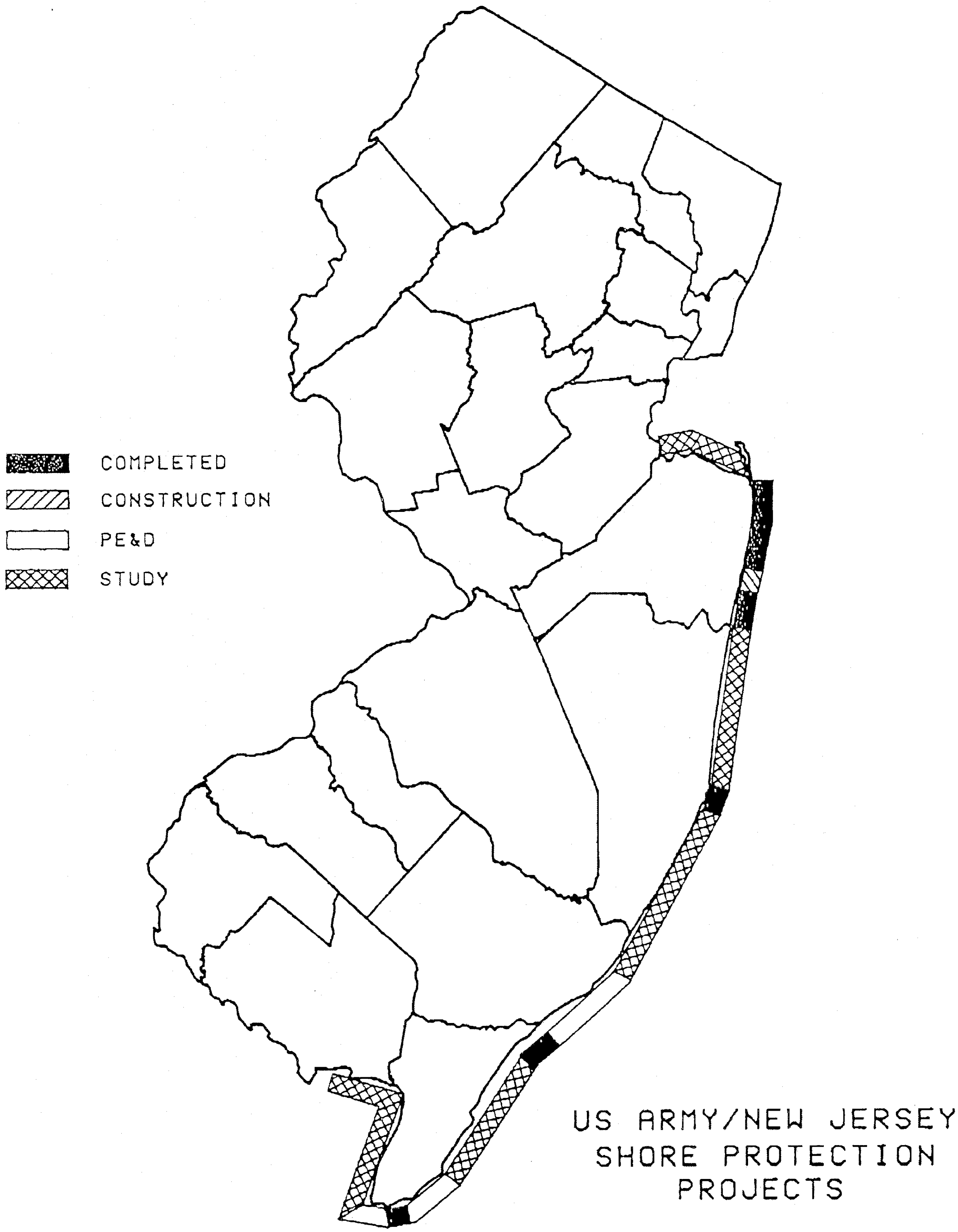
I have also enclosed for your information a spreadsheet showing the status and estimated funding requirements for the US Army/state/local Shore Protection Program. I hope this information is useful in determining an appropriate allocation of funds. If you have any questions, please feel free to contact Bernard J. Moore, Administrator, Division of Engineering & Construction, 1510 Hooper Avenue, Toms River, New Jersey, 08753, or at (732)255-0770.

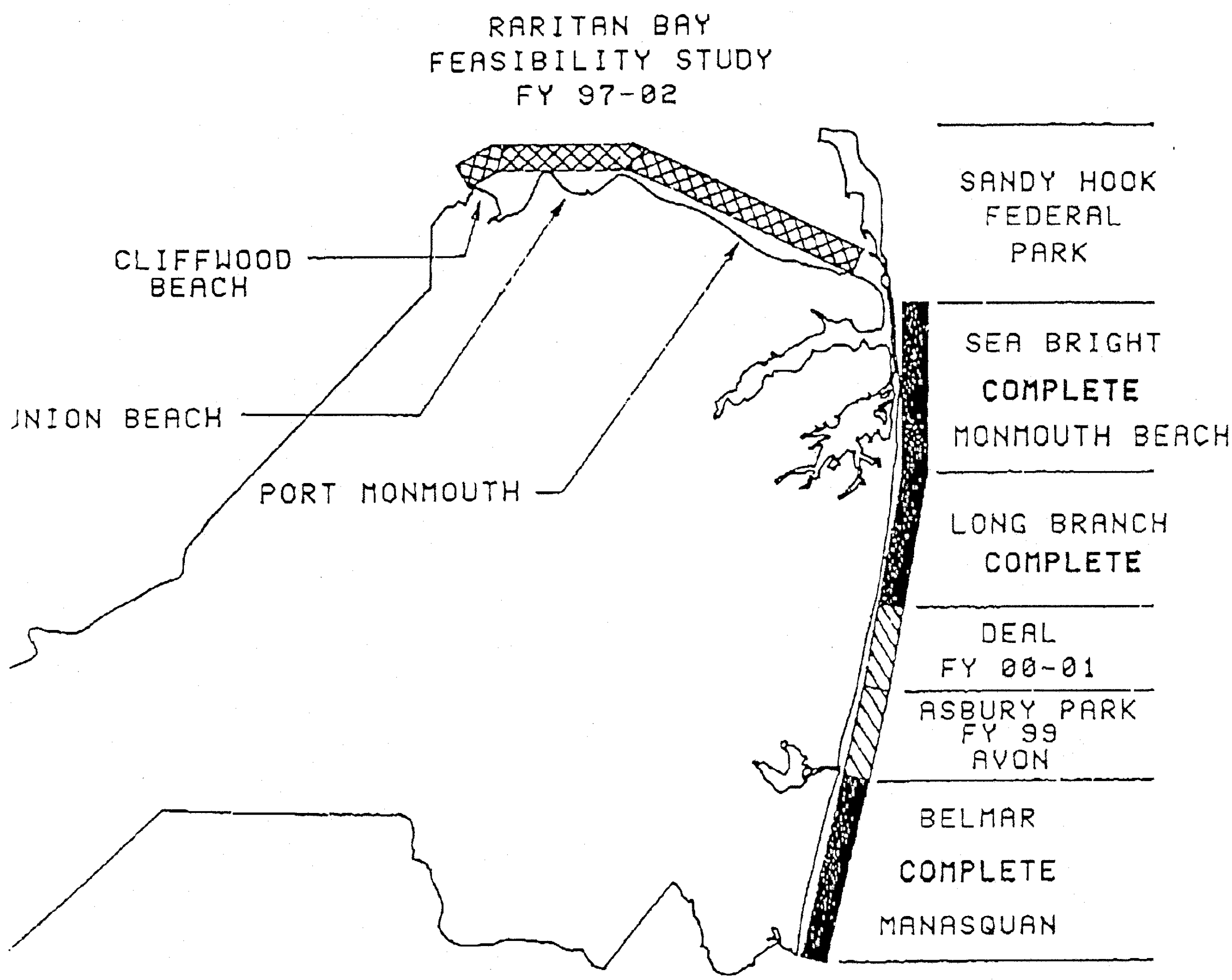
Sincerely,

Robert C. Shinn, Jr.
Commissioner

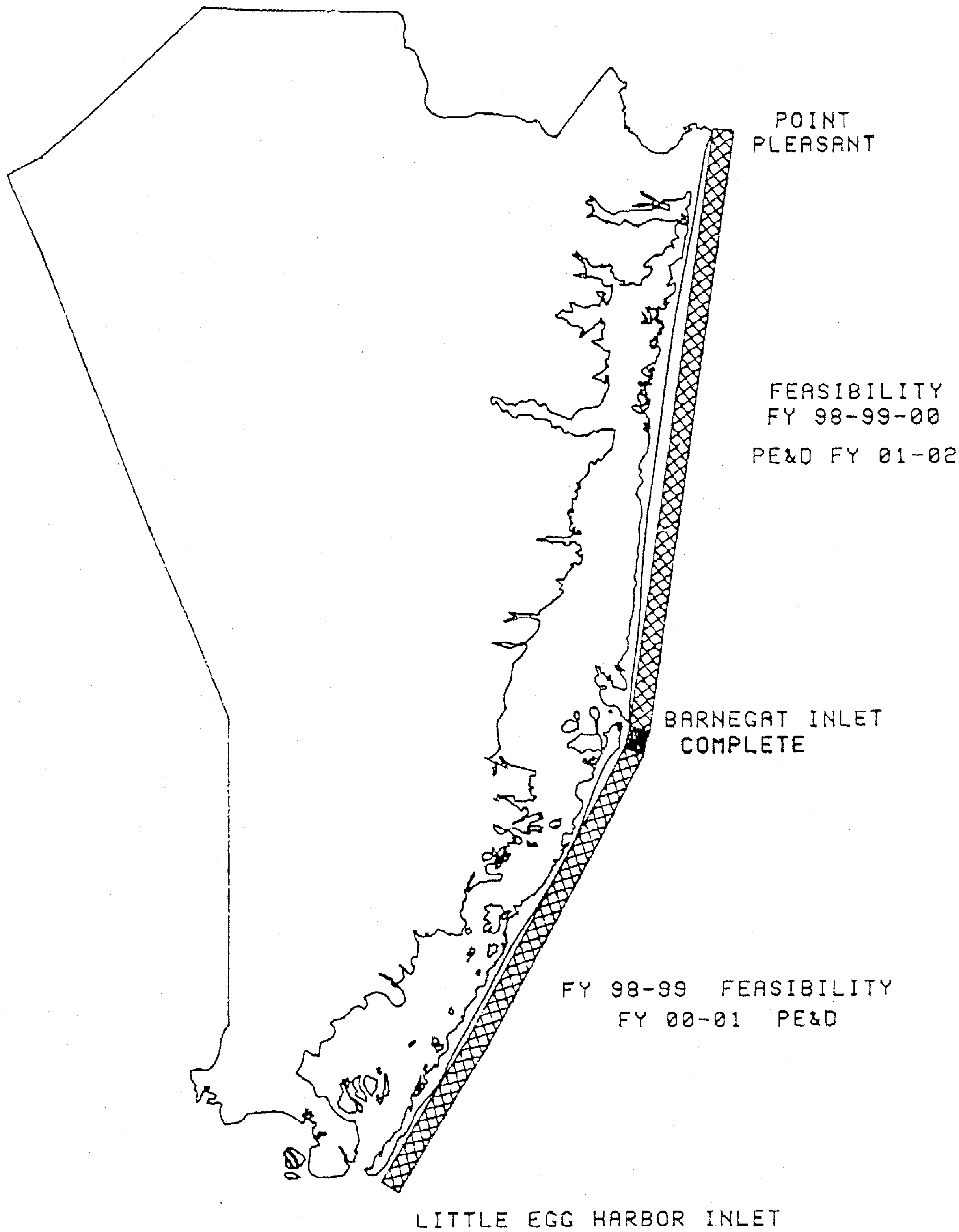
Enclosures

c. Lawrence C. Schmidt
Haig Kasabach
Bernard J. Moore

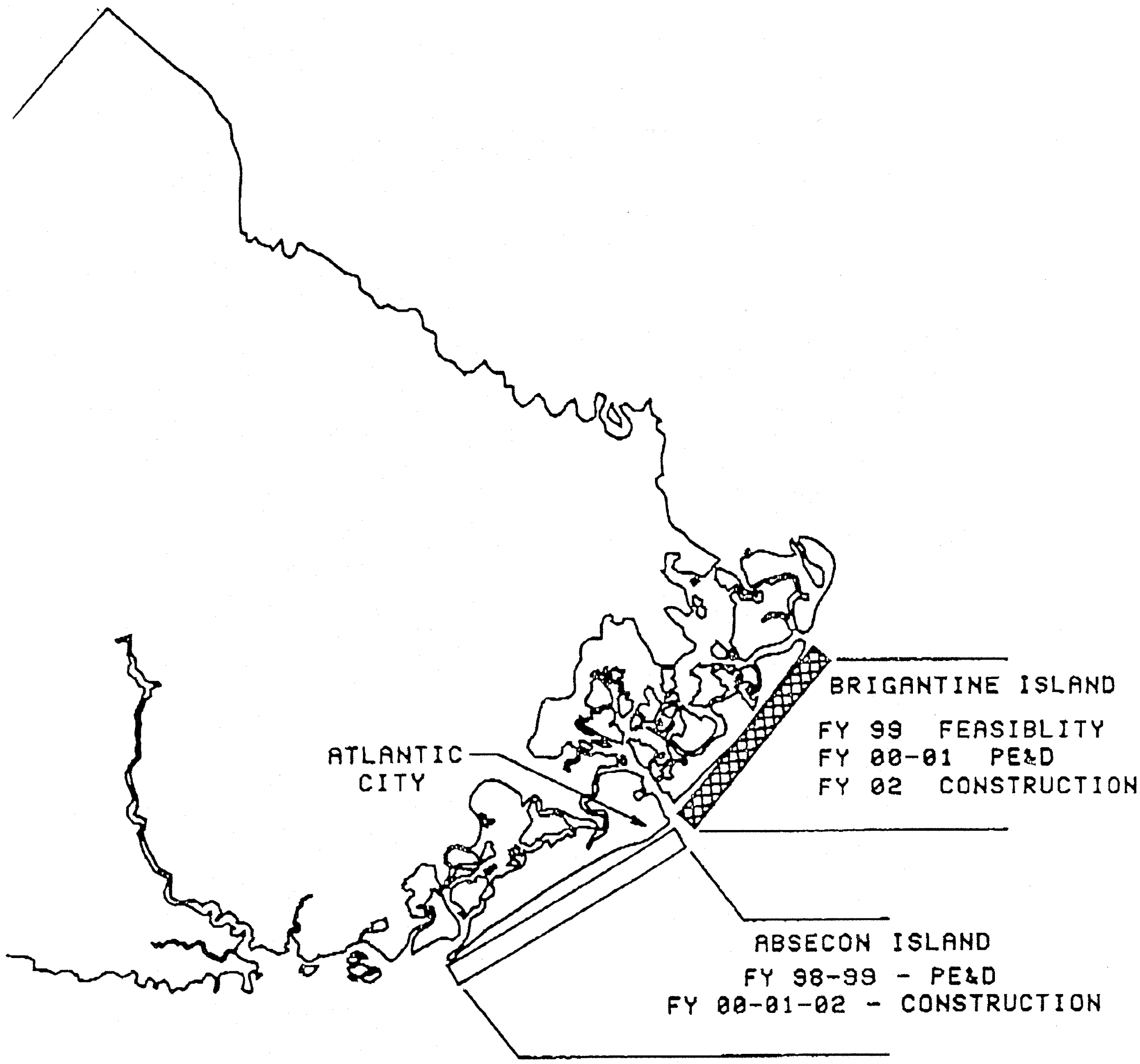

COMPLETED
CONSTRUCTION
PE&D
STUDY
US ARMY/NEW JERSEY
SHORE PROTECTION
PROJECTS



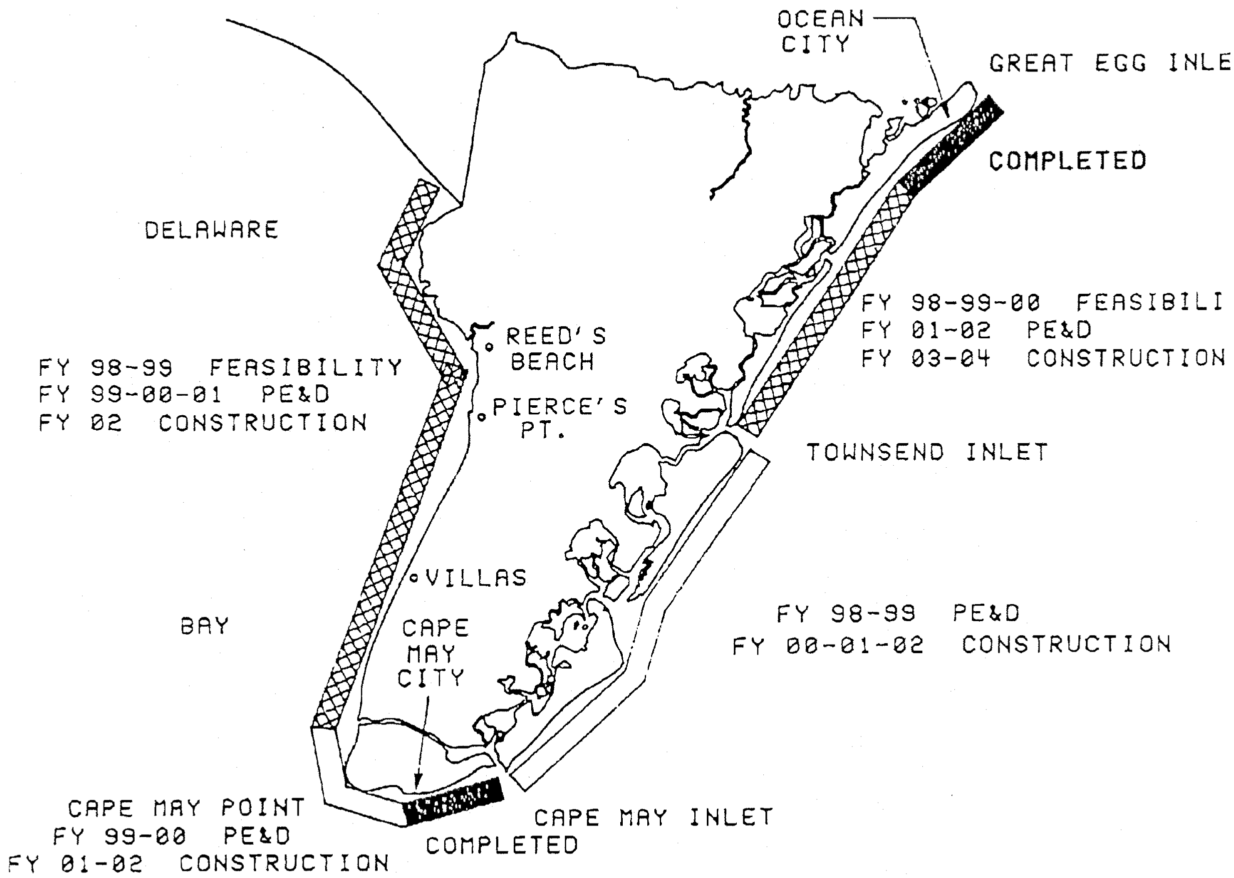
MONMOUTH COUNTY



OCEAN COUNTY

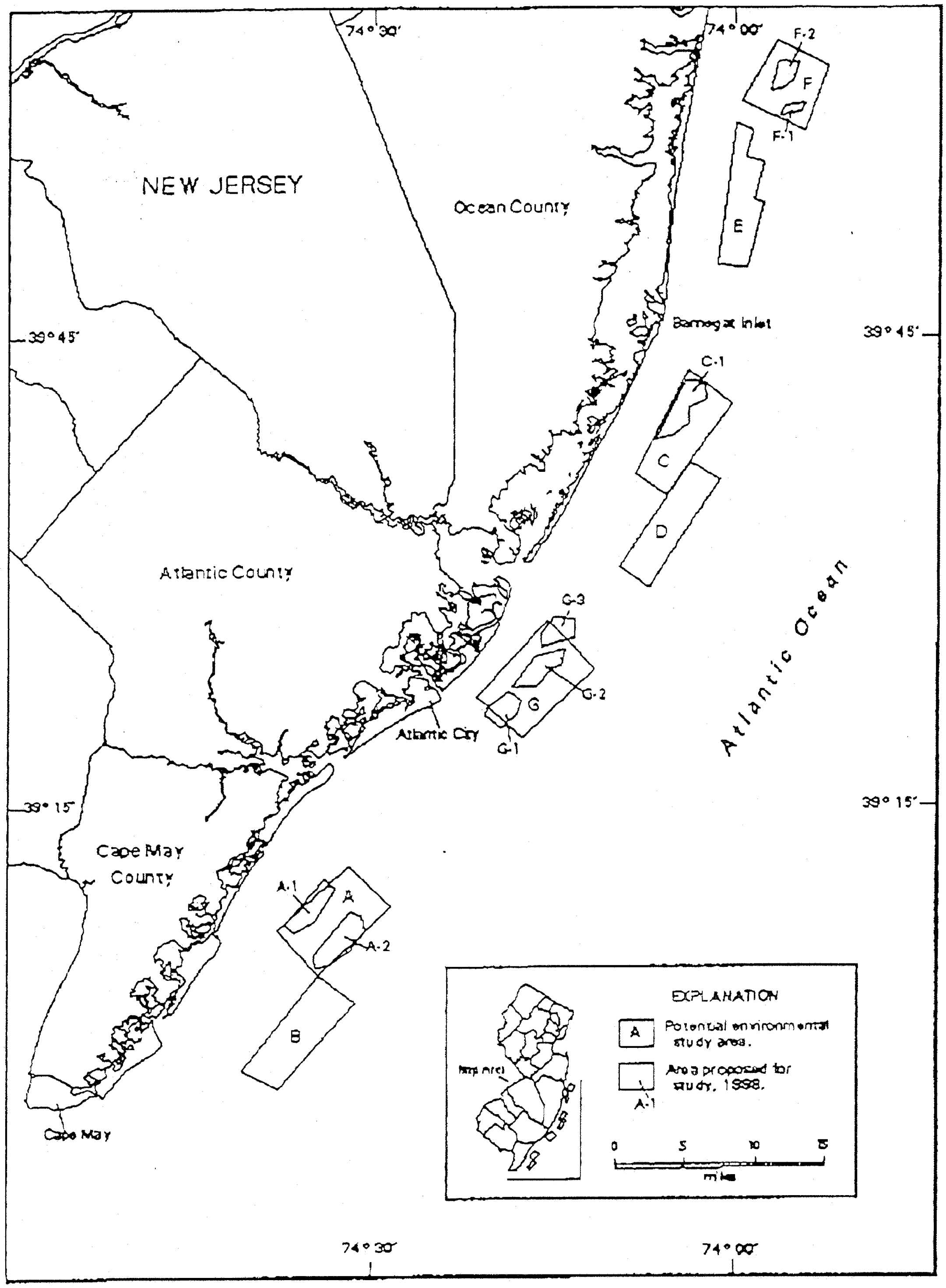


ATLANTIC COUNTY



CAPE MAY COUNTY

Targeted Sand Source Areas in Federal Waters



	A	B	C	D	E	F	G	H	I	J	K	L
1												
2					US ARMY-STATE LOCAL-SHORE PROTECTION PROJECTS							
3												
4					STATUS AND ESTIMATED FUNDING REQUIRED							
5						8-Jan-99						
6												
7	AREA	ACTION	FY 98	FY 99	FY 00	FY 01	FY 02	FY 03	FY 04	FY 05	FY 06	FY 07
8												
9	RARITAN BAY	FEAS. FEDERAL	$275,000.00	$225,000.00	$200,000.00							
10	CLIFFWOOD BEACH	STATE	$275,000.00	$225,000.00	$200,000.00							
11												
12												
13	RARITAN BAY	FEAS. FEDERAL			$200,000.00	$300,000.00	$300,000.00	$200,000.00				
14	KEYPORT	STATE			$200,000.00	$300,000.00	$300,000.00	$200,000.00				
15												
16	RARITAN BAY	FEAS. FEDERAL	$570,000.00	$325,000.00	$304,000.00							
17	UNION BEACH	STATE	$889,000.00	$385,000.00	$114,000.00							
18												
19	RARITAN BAY	FEAS. FEDERAL		$100,000.00	$265,000.00	$50,000.00						
20	LEONARDO	STATE		$100,000.00	$265,000.00	$50,000.00						
21												
22		CONSTR. FEDERAL					$600,000.00	$500,000.00	$400,000.00			
23		STATE					$200,000.00	$167,000.00	$135,000.00			
24												
25	RARITAN BAY	CONSTR. FEDERAL		$100,000.00	$400,000.00	$5,500,000.00	$6,500,000.00					
26	PORT MONMOUTH	STATE		$34,000.00	$100,000.00	$2,600,000.00	$2,600,000.00					
27		LOCAL				$900,000.00	$900,000.00					
28												
29	RARITAN BAY	FEAS. FEDERAL			$200,000.00	$300,000.00	$300,000.00	$200,000.00				
30	HIGHLANDS	STATE			$200,000.00	$300,000.00	$300,000.00	$200,000.00				
31												
32	SEA BRIGHT	CONSTR. FEDERAL				$14,400,000.00						$14,400,000.00
33	MONMOUTH BEACH	STATE				$5,000,000.00						$5,000,000.00
34		LOCAL				$1,800,000.00						$1,800,000.00
35												
36	LONG BRANCH	CONSTR. FEDERAL	$20,908,000.00	$7,106,000.00					$7,200,000.00			
37		STATE	$8,444,000.00	$2,870,000.00					$2,900,000.00			
38		LOCAL	$2,814,000.00	$957,000.00					$900,000.00			
39												
40	DEAL TO ASBURY	CONSTR. FEDERAL			$23,463,000.00	$23,463,000.00						$7,000,000.00
41		STATE			$9,475,000.00	$9,475,000.00						$2,800,000.00
42		LOCAL			$3,158,000.00	$3,158,000.00						$900,000.00
43												
44	ASBURY TO AVON	CONSTR. FEDERAL		$12,235,000.00					$7,000,000.00			
45		STATE		$4,062,000.00					$2,800,000.00			
46		LOCAL		$1,653,000.00					$900,000			
47												

APPENDIX E. RELEVANT REGULATIONS

PUBLIC LAW 103-426—OCT. 31, 1994 108 STAT. 4371

Public Law 103-426
103d Congress

An Act

To authorize the Secretary of the Interior to negotiate agreements for the use of Outer Continental Shelf sand, gravel, and shell resources.

Oct. 31, 1994
(H.R. 3678)

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled,

SECTION 1. AMENDMENTS.

(a) SECTION 8 AMENDMENTS.—Section 8(k) of the Outer Continental Shelf Lands Act (43 U.S.C. 1337(k)) is amended—

(1) by inserting "(1)" after "(k)"; and

(2) by adding at the end the following new paragraph:

"(2)(A) Notwithstanding paragraph (1), the Secretary may negotiate with any person an agreement for the use of Outer Continental Shelf sand, gravel and shell resources—

"(i) for use in a program of, or project for, shore protection, beach restoration, or coastal wetlands restoration undertaken by a Federal, State, or local government agency; or

"(ii) for use in a construction project, other than a project described in clause (i), that is funded in whole or part by or authorized by the Federal Government.

"(B) In carrying out a negotiation under this paragraph, the Secretary may assess a fee based on an assessment of the value of the resources and the public interest served by promoting development of the resources. No fee shall be assessed directly or indirectly under this subparagraph against an agency of the Federal Government.

"(C) The Secretary may, through this paragraph and in consultation with the Secretary of Commerce, seek to facilitate projects in the coastal zone, as such term is defined in section 304 of the Coastal Zone Management Act of 1972 (16 U.S.C. 1453), that promote the policy set forth in section 303 of that Act (16 U.S.C. 1452).

"(D) Any Federal agency which proposes to make use of sand, gravel and shell resources subject to the provisions of this Act shall enter into a Memorandum of Agreement with the Secretary concerning the potential use of those resources. The Secretary shall notify the Committee on Merchant Marine and Fisheries and the Committee on Natural Resources of the House of Representatives and the Committee on Energy and Natural Resources of the Senate on any proposed project for the use of those resources prior the use of those resources.".

(b) SECTION 20 AMENDMENTS.—Section 20(a) of the Outer Continental Shelf Lands Act (43 U.S.C. 1346(a)) is amended—

(1) in paragraph (l)—

(A) by inserting "or other lease" after "any oil and gas lease sale"; and

(B) by inserting "or other mineral" after "affected by oil and gas"; and,

(2) in paragraph (2), by inserting "In the case of an agreement under section 8(k)(2), each study required by paragraph (1) of this subsection shall be commenced not later than 6 months prior to commencing negotiations for such agreement or the entering into the memorandum of agreement as the case may be." after "scheduled before such date of enactment,".

Approved October 31, 1994.

LEGISLATIVE HISTORY—H.R. 3678:
HOUSE REPORTS: No 103-817, Pt. 1, (Comm. on Natural Resources).
CONGRESSIONAL RECORD, Vol 140 (1994);
Oct. 3, considered and passed House
Oct. 6, considered and passed Senate.

all land, easements, rights-of-way, dredged material disposal areas, and relocations necessary for such projects.

(C) CREDIT.—The value of such land, easements, rights-of-way, dredged material disposal areas, and relocations shall be credited toward the payment required under this paragraph.

(3) STRUCTURAL FLOOD CONTROL PROJECTS.—Any structural flood control projects carried out under this section shall be subject to cost sharing in accordance with section 103(a) of the Water Resources Development Act of 1986 (33 U.S.C. 2213(a)).

(4) OPERATION AND MAINTENANCE.—The non-Federal interests shall be responsible for all costs associated with operating, maintaining, replacing, repairing, and rehabilitating all projects carried out under this section.

(d) PROJECT JUSTIFICATION.—

(1) IN GENERAL.—Notwithstanding any other provision of law or requirement for economic justification established under section 209 of the Flood Control Act of 1970 (42 U.S.C. 1962-2), the Secretary may implement a project under this section if the Secretary determines that the project—

(A) will significantly reduce potential flood damages;

(B) will improve the quality of the environment; and

(C) is justified considering all costs and beneficial outputs of the project.

(2) ESTABLISHMENT OF SELECTION AND RATING CRITERIA AND POLICIES.—

(A) IN GENERAL.—Not later than 180 days after the date of enactment of this Act, the Secretary, in cooperation with State and local agencies and tribes, shall—

(i) develop, and submit to the Committee on Transportation and Infrastructure of the House of Representatives and the Committee on Environment and Public Works of the Senate, criteria for selecting and rating projects to be carried out under this section; and

(ii) establish policies and procedures for carrying out the studies and projects undertaken under this section.

(B) CRITERIA.—The criteria referred to in subparagraph (A)(i) shall include, as a priority, the extent to which the appropriate State government supports the project.

(e) PRIORITY AREAS.—In carrying out this section, the Secretary shall examine appropriate locations, including—

(1) Pima County, Arizona, at Paseo De Las Iglesias and Rillito River;

(2) Coachella Valley, Riverside County, California;

(3) Los Angeles and San Gabriel Rivers, California;

(4) Murrieta Creek, California;

(5) Napa River Valley watershed, California, at Yountville, St Helena, Calistoga, and American Canyon;

(6) Santa Clara basin, California, at Upper Guadalupe River and Tributaries, San Francisquito Creek, and Upper Penitencia Creek;

(7) Pond Creek, Kentucky;

(8) Red River of the North, Minnesota, North Dakota, and South Dakota;

(9) Connecticut River, New Hampshire;

(10) Pine Mount Creek, New Jersey;

(11) Southwest Valley, Albuquerque, New Mexico;

(12) Upper Delaware River, New York;

(13) Briar Creek, North Carolina;

(14) Chagrin River, Ohio;

(15) Mill Creek, Cincinnati, Ohio;

(16) Tillamook County, Oregon,

(17) Willamette River basin, Oregon;

(18) Blair County, Pennsylvania, at Altoona and Frankstown Township;

(19) Delaware River, Pennsylvania;

(20) Schuylkill River, Pennsylvania;

(21) Providence County, Rhode Island;

(22) Shenandoah River, Virginia; and

(23) Lincoln Creek, Wisconsin.

(f) PROGRAM REVIEW.—

(1) IN GENERAL.—The program established under this section shall be subject to an independent review to evaluate the efficacy of the program in achieving the dual goals of flood hazard mitigation and riverine restoration.

(2) REPORT.—Not later than April 15, 2003, the Secretary shall submit to the Committee on Transportation and Infrastructure of the House of Representatives and the Committee on Environment and Public Works of the Senate a report on the findings of the review conducted under this subsection with any recommendations concerning continuation of the program.

(g) MAXIMUM FEDERAL COST PER PROJECT.—Not more than $30,000,000 may be expended by the United States on any single project under this section.

(h) PROCEDURE.—

(1) ALL PROJECTS.—The Secretary shall not implement any project under this section until—

(A) the Secretary submits to the Committee on Environment and Public Works of the Senate and the Committee on Transportation and Infrastructure of the House of Representatives a written notification describing the project and the determinations made under subsection (d)(1); and

(B) 21 calendar days have elapsed after the date on which the notification was received by the committees.

(2) PROJECTS EXCEEDING $15,000,000.—

(A) LIMITATION ON APPROPRIATIONS.—No appropriation shall be made to construct any project under this section the total Federal cost of construction of which exceeds $15,000,000 if the project has not been approved by resolutions adopted by the Committee on Transportation and Infrastructure of the House of Representatives and the Committee on Environment and Public Works of the Senate.

(B) REPORT.—For the purpose of securing consideration of approval under this paragraph, the Secretary shall submit a report on the proposed project, including all relevant data and information on all costs.

(i) AUTHORIZATION OF APPROPRIATIONS.—

(1) IN GENERAL.—There are authorized to be appropriated to carry out this section—

(A) $20,000,000 for fiscal year 2001;

(B) $30,000,000 for fiscal year 2002; and

(C) $50,000,000 for each of fiscal years 2003 through 2005.

(2) FULL FUNDING.—All studies and projects carried out under this section from Army Civil Works appropriations shall be fully funded within the program funding levels provided in this subsection.

SEC. 213. SHORE MANAGEMENT PROGRAM.

(a) REVIEW.—The Secretary shall review the implementation of the Corps of Engineers shore management program, with particular attention to—

(1) inconsistencies in implementation among the divisions and districts of the Corps of Engineers; and

(2) complaints by or potential inequities regarding property owners in the Savannah District, including an accounting of the number and disposition of complaints in the Savannah District during the 5-year period preceding the date of enactment of this Act.

(b) REPORT.—As expeditiously as practicable, but not later than 1 year after the date of enactment of this Act, the Secretary shall submit to the Committee on Transportation and Infrastructure of the House of Representatives and the Committee on Environment and Public Works of the Senate a report describing the results of the review under subsection (a).

SEC. 214. SHORE DAMAGE PREVENTION OR MITIGATION.

Section 111 of the River and Harbor Act of 1968 (33 U.S.C. 426i) is amended—

(1) in the first sentence—

(A) by striking "The Secretary" and inserting "(a) IN GENERAL.—The Secretary"; and

(B) by inserting after "navigation works" the following: "and shore damage attributable to the Atlantic Intracoastal Waterway and the Gulf Intracoastal Waterway";

(2) in the second sentence, by striking "The costs" and inserting the following:

"(b) COST SHARING.—The costs";

(3) in the third sentence—

(A) by striking "No such" and inserting the following:

"(c) REQUIREMENT FOR SPECIFIC AUTHORIZATION.—No such"; and

(B) by striking "$2,000,000" and inserting "$5,000,000"; and

(4) by adding at the end the following:

"(d) COORDINATION.—The Secretary shall—

"(1) coordinate the implementation of the measures under this section with other Federal and non-Federal shore protection projects in the same geographic area; and

"(2) to the extent practicable, combine mitigation projects with other shore protection projects in the same area into a comprehensive regional project.".

SEC. 215. SHORE PROTECTION.

(a) PERIODIC NOURISHMENT.—Section 103(d) of the Water Resources Development Act of 1986 (33 U.S.C. 2213(d)) is amended—

(1) by striking "Costs of constructing" and inserting the following:

"(1) CONSTRUCTION.—Costs of constructing"; and

(2) by adding at the end the following:

"(2) PERIODIC NOURISHMENT.—

"(A) IN GENERAL.—In the case of a project authorized for construction after December 31, 1999, or for which a feasibility study is completed after that date, the non-Federal cost of the periodic nourishment of the project, or any measure for shore protection or beach erosion control for the project, that is carried out—

"(i) after January 1, 2001, shall be 40 percent;

"(ii) after January 1, 2002, shall be 45 percent; and

"(iii) after January 1, 2003, shall be 50 percent.

"(B) BENEFITS TO PRIVATELY OWNED SHORES.—All costs assigned to benefits of periodic nourishment projects or measures to privately owned shores (where use of such shores is limited to private interests) or to prevention of losses of private land shall be borne by the non-Federal interest.

"(C) BENEFITS TO FEDERALLY OWNED SHORES.—All costs assigned to the protection of federally owned shores for periodic nourishment measures shall be borne by the United States.".

(b) OUTER CONTINENTAL SHELF.—

(1) USE OF SAND FROM OUTER CONTINENTAL SHELF.—Section 8(k)(2)(B) of the Outer Continental Shelf Lands Act (43 U.S.C. 1337(k)(2)(B)) is amended in the second sentence by striking "an agency of the Federal Government" and inserting "a Federal, State, or local government agency".

(2) REIMBURSEMENT OF LOCAL INTERESTS.—Any amounts paid by non-Federal interests for beach erosion control, hurricane protection, shore protection, or storm damage reduction projects as a result of an assessment under section 8(k) of the Outer Continental Shelf Lands Act (43 U.S.C. 1337(k)) shall be fully reimbursed.

(c) REPORT ON SHORES OF THE UNITED STATES.—

(1) IN GENERAL.—Not later than 3 years after the date of enactment of this Act, the Secretary shall report to Congress on the state of the shores of the United States.

(2) CONTENTS.—The report shall include—

(A) a description of—

(i) the extent of, and economic and environmental effects caused by, erosion and accretion along the shores of the United States; and

(ii) the causes of such erosion and accretion;

(B) a description of resources committed by Federal, State, and local governments to restore and renourish shores;

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FEES FOR OCS SAND

Issue: Legislation eliminating fees for OCS sand resources

Status: On August 17, 1999, President Clinton signed the Water Resources Development Act of 1999. One provision of the Act amended Section 8(k)(1)(B) of the OCSLA to prohibit MMS from charging fees to State and local governments for shore protection projects. The Water Resources Development Act also included a provision authorizing reimbursement of fees to any parties that had been previously charged a fee. The only local government charged a fee was the City of Virginia Beach ($198,000) for a beach renourishment project in 1998. This fee was submitted through the Royalty Management Program to the Treasury.

It is likely Congress will address an appropriation for $198,000 to reimburse Virginia in conjunction with the Interior Appropriations Bill.

Background:
Public Law 103-426, passed by Congress in 1994, amended section 8(k) of the OCS Lands Act to authorize a negotiated agreement process (in lieu of a competitive bidding process) thus removing a procedural obstacle when OCS sand (and gravel and shell) are needed for certain publicly-beneficial beach nourishment and wetlands restoration projects undertaken by Federal, State, or local government agencies. The amendment also provided that the Secretary may assess a fee for use of those resources based on an assessment of the value of the resource and the public interest served by developing the OCS resource. The amendments included in WRDA 1999 eliminated fees for shore protection projects undertaken by State and local governments.

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MEMORANDUM OF AGREEMENT
BETWEEN
MINERALS MANAGEMENT SERVICE
U.S. DEPARTMENT OF THE INTERIOR
AND
U.S. ARMY CORPS OF ENGINEERS
DEPARTMENT OF THE ARMY

I. Introduction

The Minerals Management Service (MMS) and the United States Army Corps of Engineers (USACE) agree to establish procedures to assure timely coordination and cooperation between the two agencies as each carries out its responsibilities related to the use of Outer Continental Shelf (OCS) sand, gravel, and shell resources for USACE authorized shore protection projects.

The MMS recognizes the USACE's responsibilities to oversee beach renourishment and Congressionally authorized shore protection projects implemented jointly by the USACE and State or local governments. The USACE responsibilities include regulatory and project authorities under Title 33 U.S. Code.

The USACE recognizes MMS's responsibilities under P.L. 103-426 to negotiate agreements for the use of OCS sand, gravel, and shell resources for shore protection, beach restoration, or coastal wetlands restoration undertaken by a Federal, State, or local government agency, as well as for use in a construction project that is funded in whole or part by or authorized by the Federal Government.

II. Procedures

The MMS and the USACE recognize that planning and coordination between the agencies will ensure that responsibilities under the OCS Lands Act and specific Congressionally authorized projects are carried out and accommodated in an efficient and timely manner so that USACE project schedules will not be unnecessarily delayed or compromised. In addition, the MMS and the USACE acknowledge that while the specific provisions of each shore protection/renourishment project may differ, there are procedures common to all projects. To that end, the MMS and the USACE agree to the following:

1. When a decision is made to consider the use of OCS sand, gravel, or shell for an emergency protection or renourishment project, the USACE will notify the MMS and identify the potential borrow area.

2. The appropriate USACE District Office will schedule an initial meeting with MMS's International Activities and Marine Minerals Division to discuss the project and facilitate the use of each agency's environmental and other relevant data and expertise. This cooperative interaction is to ensure that each agency fully complies with the government's responsibilities under the National Environmental Policy Act (NEPA), NEPA implementing regulations of the Council on Environmental Quality, and other appropriate laws and regulations. Among the information exchanged at that meeting will be:

   a. Specific information about sand, gravel, and shell deposits in OCS waters suitable for beach nourishment as identified through MMS's cooperative efforts with coastal States.

   b. The MMS's ongoing environmental studies to assist in the analysis of potential effects regarding the use of sand, gravel, and shell deposits in OCS waters suitable for beach nourishment. The MMS will make these studies available to the USACE to assist in the project specific environmental analyses. The MMS's possible participation in the environmental analysis will also be discussed.

   c. The USACE will provide to the MMS relevant environmental studies that the USACE has available for its project and applicable schedules for the project.

3. After the environmental analyses for the project are complete and a decision is made to use OCS sand, the MMS and the USACE will enter into a project-specific Memorandum of Agreement (MOA) as required by the OCS Lands Act. This MOA will include provisions, terms, and stipulations specific to the project.

4. For those projects in which the sand is transferred to a State or locality, the MMS will enter into a negotiated agreement with that State or locality. In those instances where the sand is being transferred to another Federal agency, the MOA will include the other Federal entity.

III. Summary

The MMS and the USACE are committed to carrying out their respective responsibilities regarding the use of OCS sand, gravel, and shell resources for shore protection, beach restoration, and coastal wetland restoration. By facilitating the use of available resources, the coordinating procedures set forth in this MOA will benefit State and local governments as well as thc MMS and the USACE.

U.S. DEPARTMENT OF THE INTERIOR

Sylvia Baca, Acting Assistant Secretary, Land and Minerals Management

Date

U.S. DEPARTMENT OF THE ARMY

Joe N. Ballard, Lieutenant General Chief of Engineers

21 APR 1999

Date

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